

Railway applications — Track — Switches and crossings —

Part 9: Layouts

ICS 45.080

National foreword

This British Standard is the UK implementation of EN 13232-9:2006+A1:2011. It supersedes BS EN 13232-9:2006, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

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9: Ensemble de l'appareil

Bahnanwendungen - Oberbau - Weichen und Kreuzungen -
Teil 9: Weichenanlagen

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Foreword

This document (EN 13232-9:2006+A1:2011) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2012, and conflicting national standards shall be withdrawn at the latest by April 2012.

A1 This document has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document. **A1**

This document includes Amendment 1, approved by CEN on 2011-09-13.

This document supersedes EN 13232-9:2006.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This series of standards “Railway applications — Track — Switches and crossings” covers the design and quality of switches and crossings in flat bottom rails. The list of parts is as follows:

- *Part 1 : Definitions*
- *Part 2 : Requirements for geometric design*
- *Part 3 : Requirements for wheel/rail interaction*
- *Part 4 : Actuation, locking and detection*
- *Part 5 : Switches*
- *Part 6 : Fixed common and obtuse crossings*
- *Part 7 : Crossings with moveable parts*
- *Part 8 : Expansion devices*
- *Part 9 : Layouts*

Part 1 contains terminology used throughout all parts of the standard.

Parts 2 to 4 contain basic design guides and are applicable to all switch and crossing assemblies.

Parts 5 to 8 deal with particular types of equipment, including their tolerances. These use parts 1 to 4 as a basis.

Part 9 defines the functional and geometrical dimensions and tolerances for layout assembly.

The following terms are used within to define the parties involved in using the EN as the technical basis for a transaction:

CUSTOMER The operator or user of the equipment, or the purchaser of the equipment on the user's behalf.

SUPPLIER The body responsible for the use of the EN in response to the customer's requirements.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

The scope of this part is:

- to describe the design process of switches and crossings, and the use of the other parts of this standard;
- to define the main criteria to be taken into account during the design of the layout, including the safety and functional dimensions as well as geometrical and material aspects;
- to define the main criteria to be verified during the design approval;
- to define the geometrical and non-geometrical acceptance criteria for inspection of layouts assembled both in the fabrication plant and at track site in case of layouts that are delivered non or partially assembled or in a “kit” form;
- to determine the limits of supply;
- to define the minimum requirements for traceability.

This European Standard applies only to layouts that are assembled in the manufacturing plant or that are assembled for the first time at trackside.

Other aspects such as installation and maintenance also influence performance; these are not considered as part of this European Standard.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13145, *Railway applications — Track — Wood sleepers and bearers*

EN 13230-4, *Railway applications — Track — Concrete sleepers and bearers — Part 4: Prestressed bearers for switches and crossings*

EN 13232-2, *Railway applications — Track — Switches and crossings — Part 2: Requirements for geometric design*

EN 13232-3, *Railway applications — Track — Switches and crossings — Part 3: Requirements for wheel/rail interaction*

EN 13232-4, *Railway applications — Track — Switches and crossings — Part 4: Actuation, locking and detection*

EN 13232-5, *Railway applications — Track — Switches and crossings — Part 5: Switches*

EN 13232-6, *Railway applications — Track — Switches and crossings — Part 6: Fixed common and obtuse crossings*

EN 13232-7, *Railway applications — Track — Switches and crossings — Part 7: Crossings with moveable parts*

prEN 13232-8, *Railway applications — Track — Switches and crossings — Part 8: Expansion devices*

EN 13481 (all parts), *Railway applications — Track — Performance requirements for fastening systems*

EN 13674-1, *Railway applications — Track — Rail — Part 1: Vignole railway rails 46 kg/m and above*

EN 13674-2, *Railway applications — Track — Rail — Part 2: Switch and crossing rails used in conjunction with Vignole railway rails 46 kg/m and above*

EN 13674-3, *Railway applications — Track — Rail — Part 3: Check rails*

EN 13674-4, *Railway applications — Track — Rail — Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m*

EN 13715, *Railway applications — Wheelsets and bogies — Wheels — Tread profile*

prEN 13803-2, *Railway applications — Track alignment design parameters — Track gauges 1 435 mm and wider — Part 2: Switches and crossings and comparable alignment design situations with abrupt changes of curvature*

prEN 14730 (all parts), *Railway applications — Track — Aluminothermic welding of rails*

UIC 505-1, *Railway transport stock — Rolling stock construction gauge*

UIC 505-4, *Effects of the application of the kinematic gauges defined in the 505 series of leaflets on the positioning of structures in relation to the tracks and of the tracks in relation to each other*

UIC 510-2, *Trailing stock — Conditions concerning the use of wheels of various diameters with running gear of different types*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1

guiding force Y

lateral force, acting parallel to the running surface, between the wheel and the relevant track component (usually a rail)

3.2

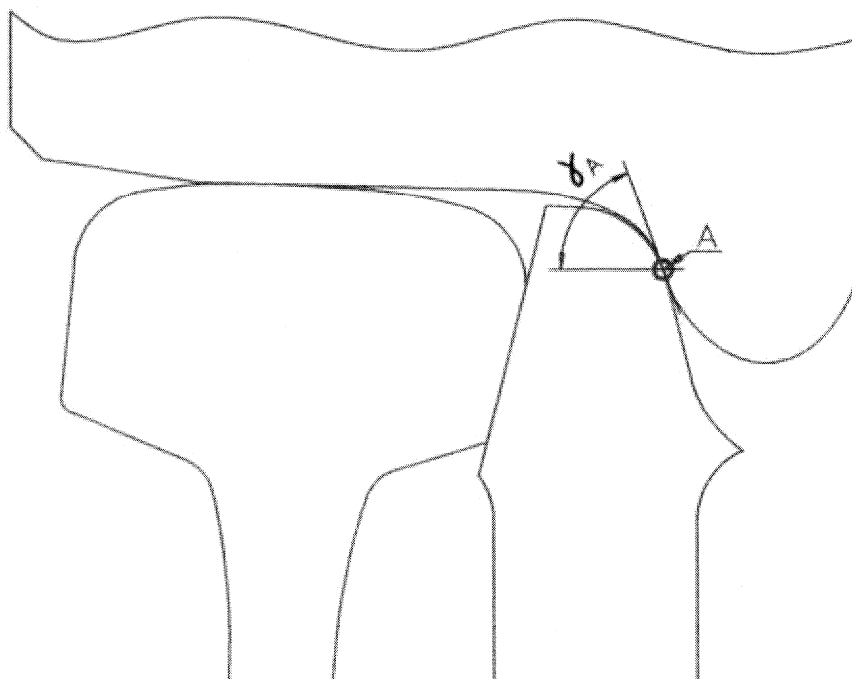
wheel load Q

force, acting perpendicular to the running surface, between the wheel on one hand and the relevant track component (rail)

3.3

contact angle γ_A

angle of the contact plane, measured at the contact point A between the wheel and the track component. In the case of a two-point contact, the one nearest the wheel flange will be considered.



Key

- γ_A contact angle
- A contact point

Figure 1 — Contact angle

This contact angle determines the contact danger zone on the wheel, as defined in EN 13232-3

3.4

friction coefficient μ

friction coefficient encountered at the contact point where the contact angle is determined

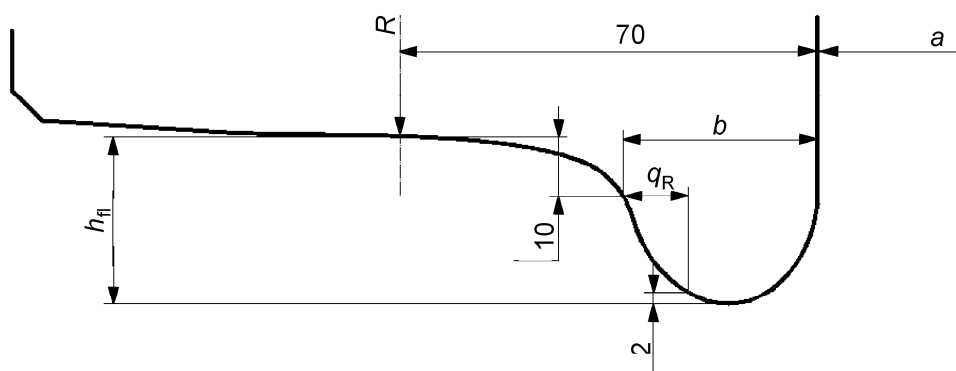
3.5

flange sharpness q_R

parameter which characterises the sharpness of the wheel flange. The measurement is taken in accordance with UIC 510-2 at the active side of the flange as defined in Figure 2. It is the distance, parallel to the wheel axis, between the following two points:

- reference point on the profile, at a distance from wheel axis of 10 mm more than the wheel radius;
- reference point located at a distance 2 mm from the flange tip towards the wheel axis

Dimensions in millimetres



Key

a wheel back to back
 b flange width
 h_f flange depth

q_R flange sharpness
 R wheel radius

Figure 2 — Wheel parameters

3.6

flange depth h_f
see EN 13232-3

3.7

wheel back-to-back a

see EN 13232-2. The symbol " a " is used throughout this standard. An index max or min is given to this symbol according respectively to the maximum and minimum values that can occur during operation

3.8

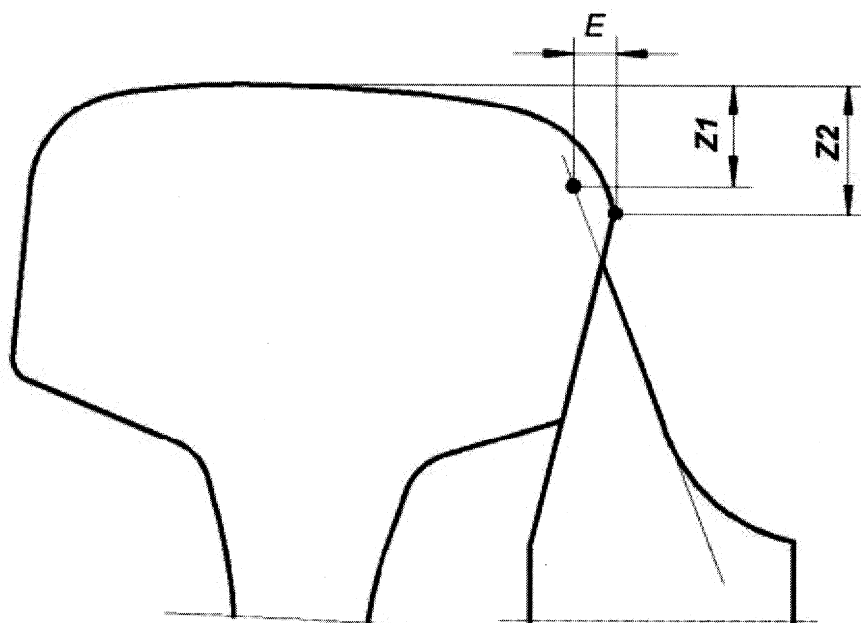
flange width b

see EN 13232-2. The symbol " b " is used throughout this standard. An index max or min is given to this symbol according respectively to the maximum and minimum values that can occur during operation

3.9

switch point retraction E

distance, measured at the reference plane, between the reference line of switch and stock rail at the actual switch toe



Key

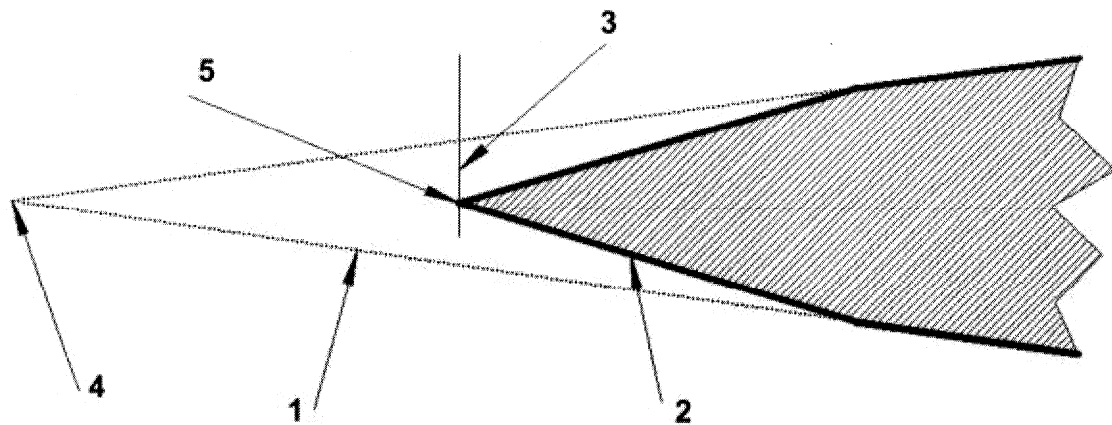
- E point retraction
- $Z1$ switch rail machining reference plane (see EN 13232-5)
- $Z2$ stock rail machining reference plane (see EN 13232-5)

Figure 3 — Switch point retraction

3.10

point retraction in fixed common crossing

reference line in a fixed common crossing which can deviate from the theoretical geometry line. From a certain distance to the crossing point, the reference line of the vee can, depending on the design, be removed from this theoretical line away from the wheel flange in order to avoid contact between both elements. This situation is described in Figure 4.



Key

- 1 theoretical reference line
- 2 actual reference line
- 3 point retraction
- 4 mathematical point (*MP*)
- 5 actual point (*RP*)

Figure 4 — Point retraction in fixed common crossing

The value of the point retraction is measured at the actual point (*RP*)

3.11

lead of turnout

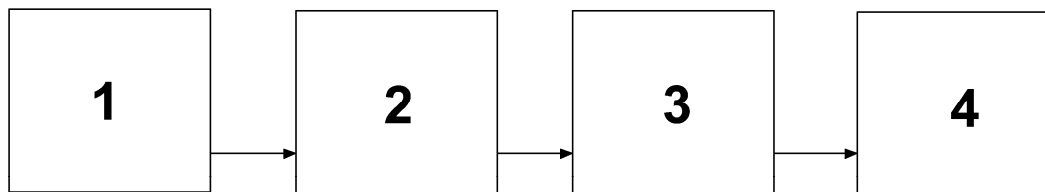
distance between reference points of the different components of the S&C, e.g. the distance between theoretical points of crossing and switch in a standard layout. The lead is measured parallel to the reference line, except when stated otherwise

4 General design process

4.1 General process

The design process of switches and crossings is complex due to the many requirements that apply and the different situations that may occur. Figure 5 gives a schematic representation of the general design process. It separates the whole process into 4 main steps:

- step 1 contains the general design of the S&C. It permits the definition of the fundamental aspects of the S&C, respecting the main design requirements, as defined in parts 2 to 4;
- step 2 is the main constructional design process, which specifies the main construction of the S&C;
- step 3 consists of the detailed design of the individual components;
- step 4 is the product acceptance.



Key

- 1 step 1: General design
- 2 step 2: Main constructional design
- 3 step 3: Detailed component design
- 4 step 4: Acceptance

Figure 5 — General design process

Step 1 consists of the geometrical design, the design of the wheel-rail interaction and the design requirements for compliance with the actuation, locking and detection system.

Step 2 is based on the technology used by the supplier and is not dealt with in detail by any standard. It is mainly based on the suppliers' experience and expertise.

Step 3 is dealt with in different standards. The design of the main components shall respect the requirements laid down in parts 5 to 8. Other components, such as fastenings, bearers, etc, are dealt with in respective EN's.

4.2 Design step details

- a) Every design step requires sufficient **input data** to enable the design to be completed.
- b) These input data are dealt with by the supplier through the **design rules**. The rules are defined in EN 13232, parts 2 to 8.
- c) The result of the different design steps are **outputs**.

All these aspects are schematically represented for each design step in Figure 6, with a reference to the different parts and clauses where these aspects are dealt with in detail.

4.3 Practical use of the design process

The previous scheme deals with the complete design process of the S&C. The use of the standard is not limited to this case only.

The customer may choose to instruct the supplier to perform the whole design process and therefore the customer would provide all the necessary input data to permit the supplier to perform the design

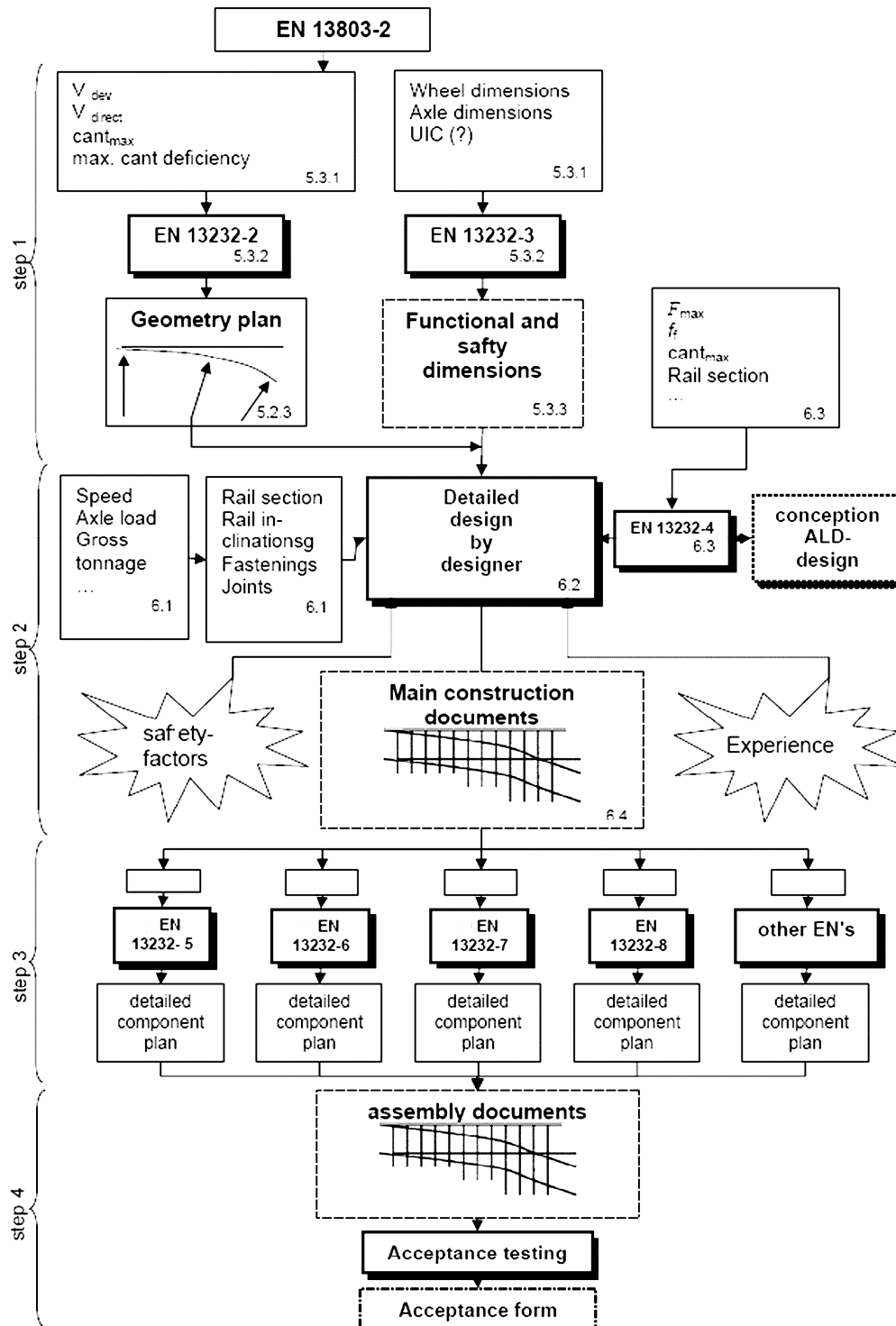
The customer may also opt to instruct the supplier to perform only parts of the design process. In this case the customer shall deliver all inputs of the design steps he has requested the supplier to perform. This means that he has to deliver all outputs of the previous design steps.

EXAMPLE 1 The customer may instruct the supplier to perform the detailed design of an S&C layout based on the geometry of an existing design for use on a main railway line. In this case the customer shall provide the supplier with the outputs from geometrical requirements (the geometry plan) as well as the requirements for wheel-rail interaction, specified by the functional and safety dimensions.

Based on this information and the inputs for both conformity for actuation, locking and detection (ALD) and general requirements, he performs the general and detailed component design.

EXAMPLE 2 The customer may instruct the supplier to fabricate an S&C layout in accordance with an existing design. He therefore shall deliver all detailed plans to the supplier. The supplier only has to do step 4 of the general design process.

A1



NOTE Subclause references in Figure 6 relate to this European Standard.

Figure 6 — Design process

A1

5 General design (design step 1)

5.1 Track layout

The track layout shall be specified in accordance with the rules laid down in prEN 13803-2.

5.2 Geometrical design

5.2.1 Inputs

The information needed to perform the geometrical design is defined in EN 13232-2. A list summarising these inputs is given in A.1.

The geometrical design process is schematically given in Figure A.1.

5.2.2 Rules

The requirements to be respected are given in EN 13232-2.

In addition to these rules the client can give additional requirements such as:

- minimum radius;
- maximum entry angle.

Basic S&C design has straight main lines (except for equal split turnouts). Curved S&C's are based on basic designs with equivalent radius.

5.2.3 Geometry plan

The geometry plan sets out the geometry design details. It contains the following information:

- gauge throughout the S&C;
- cant throughout the S&C;
- origin of switch curve;
- real switch toe;
- theoretical intersection (crossing);
- centreline radii;
- tangent offset;
- limits of supply;
- etc.

5.3 Wheel rail interaction

5.3.1 Inputs

The wheel rail interaction parameters required to perform the geometrical design are set out in EN 13232-3. A list summarising all these inputs is given in A.2.

The geometrical design process is schematically given in Figure A.2.

5.3.2 Rules

5.3.2.1 Introduction

The main rules for wheel-rail interaction are given in EN 13232-3.

These general rules are clarified in the following:

- First, the general law for derailment calculations is described. This law is to be used for safety calculations.
- Secondly, a list of commonly appearing hazardous situations is given. These situations can appear during operation and are influenced by maintenance conditions and/or design options.
- From these considerations, functional and safety dimensions are determined later in this European Standard.

5.3.2.2 Security against derailment

Security against derailment is considered to be managed by limiting the ratio of guiding force Y to actual wheel load Q . Y and Q are to be determined simultaneously. The limiting value depends on the friction coefficient μ and contact angle γ_A .

This relation is given by Equation (1) or Equation (2).

$$\frac{Y}{Q} = \frac{\tan(\gamma_A) - \mu}{1 + \mu \cdot \tan(\gamma_A)} \quad (1)$$

or, in another form:

$$\gamma_A = \arctan\left(\frac{Y}{Q}\right) + \arctan(\mu) \quad (2)$$

From this law an admissible contact angle is given, by determining an acceptable Y/Q ratio and an assumed friction coefficient μ . This admissible contact angle determines the contact danger zone on the wheel, where no contact with track components may take place to eliminate the risk of wheel climbing.

According to experiments (see ERRI C70 RP1) the contact angle γ_A shall be no smaller than 40° . This corresponds to a friction coefficient of 0,3 and Y/Q of 0,4.

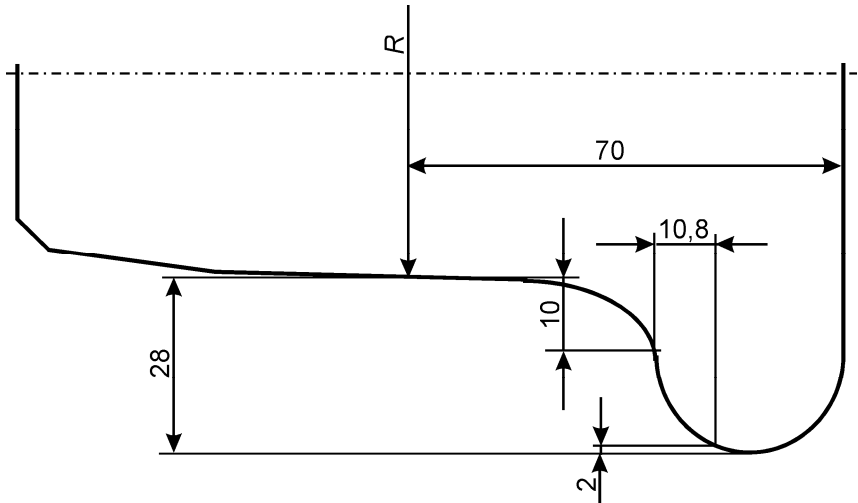
5.3.2.3 Wheels in operation

5.3.2.3.1 Wheel profiles and wear

As stated in EN 13232-3, the profiles of both new and worn wheels shall be considered. A typical new wheel profile, according to EN 13715 is given in Figure 7 for information.

Due to wear in service, the flange shape will modify significantly, especially the angle of the outside flange face. Wheel wear is characterised by q_R . See Figure 23. A minimum value of q_R shall be fixed.

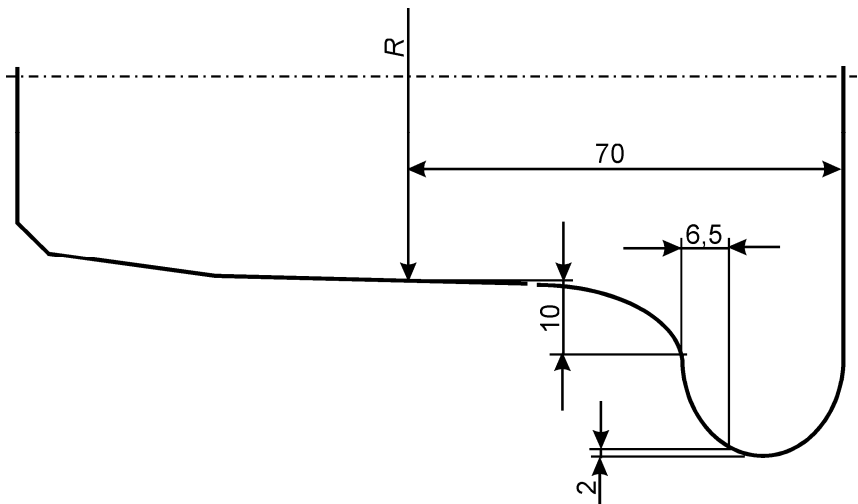
Dimensions in millimetres



Key
 R wheel radius

Figure 7 — Typical new wheel profile

Dimensions in millimetres



Key
 R wheel radius

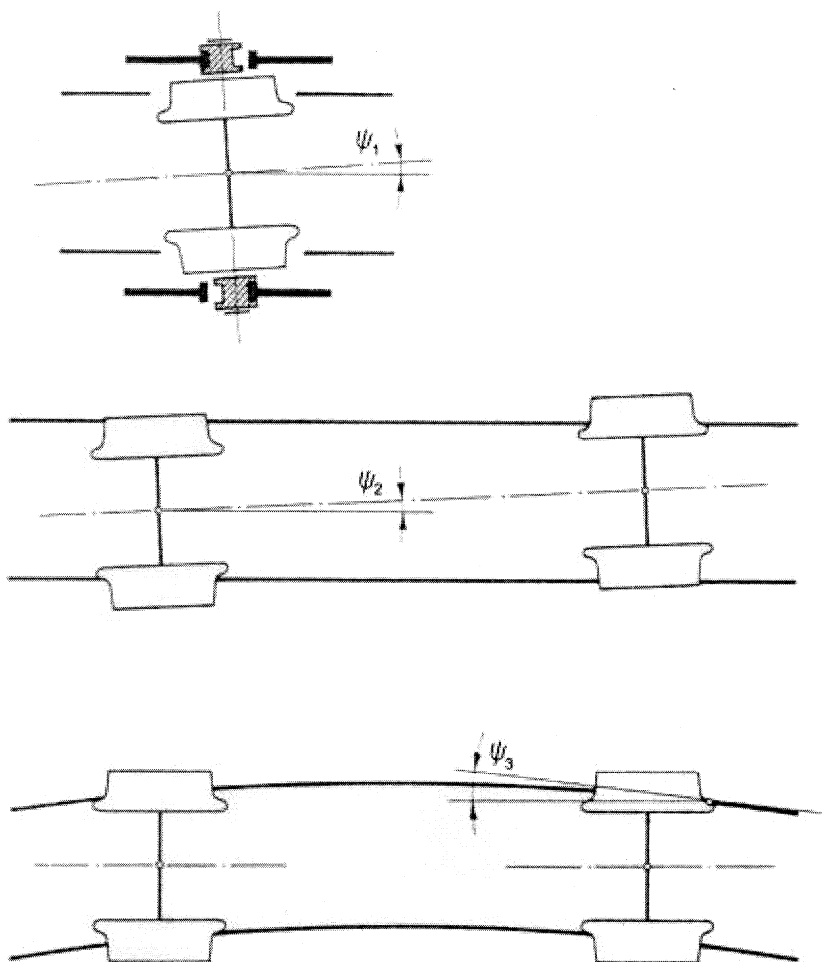
Figure 8 — Typical worn wheel profile

For operation on switches and crossings, no sharp edges or burrs may be tolerated in the transition zone between the active part of the wheel and the flange tip.

5.3.2.3.2 Angle of attack

The angle of attack is the sum of following angles (see Figure 9):

- skew ψ_1 , due to the clearances present in axle boxes;
- skew ψ_2 , due to the clearance of the wheel axles in the track;
- skew ψ_3 , i.e. the angle formed by a curved track and the parallel wheel axles of car or a bogie;
- geometrical angle of the switch, in switches and crossings, determined at the point where the wheel makes contact with the switch toe.



Key

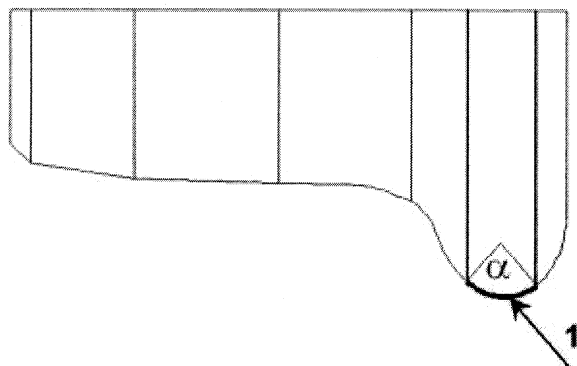
- ψ_1 skew due to clearances present in axle boxes
- ψ_2 skew due to clearance of the wheel axles in the track
- ψ_3 angle formed by a curved track and the parallel wheel axles of car or a bogie

Figure 9 — Angle of attack

5.3.2.3.3 Apparent wheel profiles

The contact point between rail and wheel can be determined by projection of the wheel onto a plane, perpendicular to the running plane. The projection of the wheel on this plane is called the apparent wheel profile.

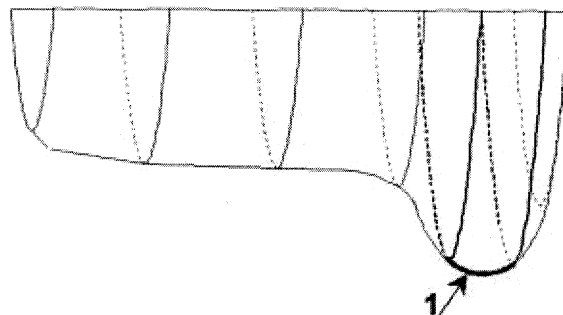
For a wheel with axis perpendicular to the track axis (angle = 0°), the apparent wheel profile is the same as the cross section of the wheel. See Figure 10. Wheel circles become straight lines by the projection (see Figure 11).



Key

- 1 Contact danger zone
- α Angle of dangerous zone

Figure 10 — Wheel with angle of attack = 0°



Key

- 1 Contact danger zone

Figure 11 — Wheel with angle of attack $\neq 0^\circ$

Due to the non-zero angle of attack ($\neq 0^\circ$), the apparent wheel profile changes as well as the contact position between wheel and rail (see Figure 11). The derailment risk is at its greatest when the contact takes place in front of the wheel as friction forces lift the wheel out of the track.

5.3.2.3.4 Tangent and secant contact

Tangent contact appears when the wheel follows a track element (rail) with a continuous profile.

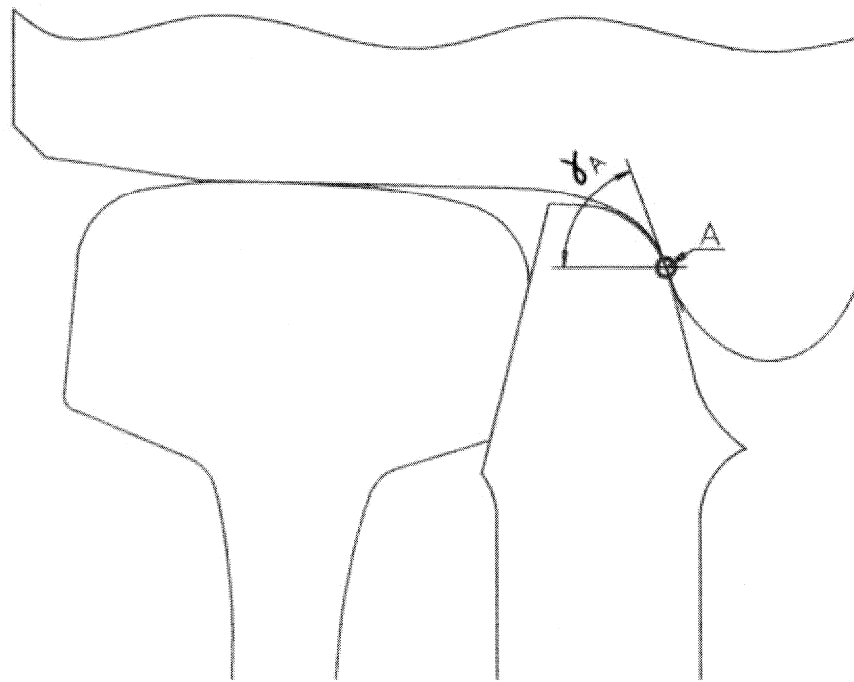
Secant contact appears when the wheel encounters an object on its route. Typical situations are:

- switch toe not protected by its stock rail;
- fixed crossing nose in case of insufficient protection by check rail;
- switch rail with damaged upper surface (tip).

5.3.2.4 Common derailment-critical situations

5.3.2.4.1 Tangent contact

The contact is similar to plain line contact. The worst case appears when a new profile with maximum angle of attack encounters the rail. In this case the contact angle γ_A will be maximum. See Figure 12.



Key

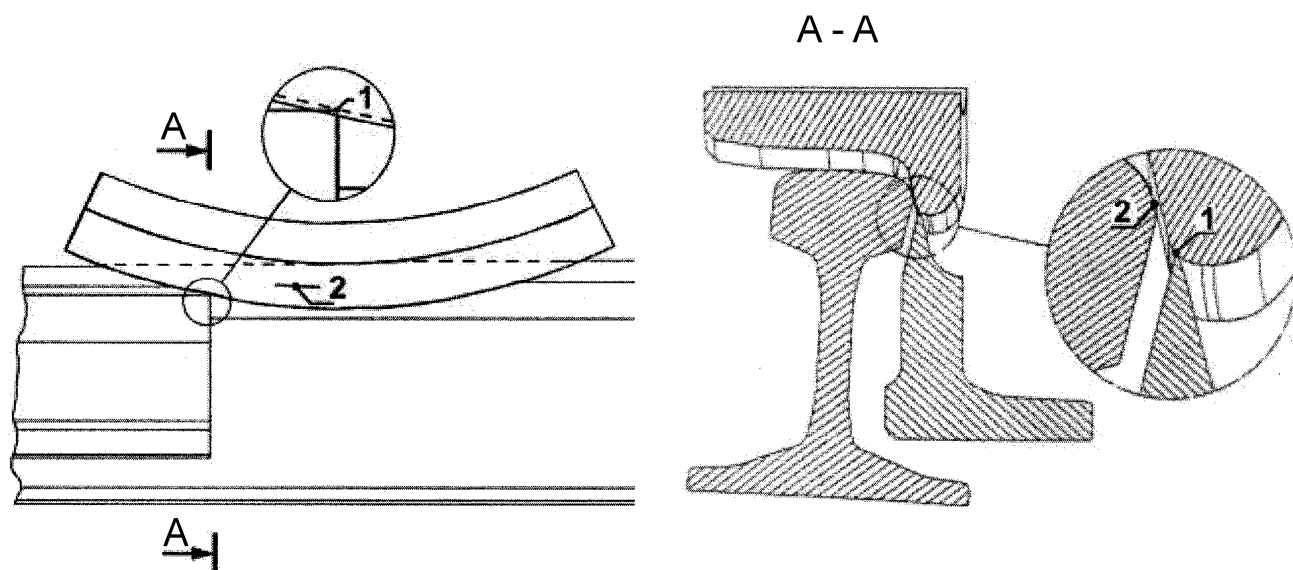
A contact point

γ_A contact angle

Figure 12 — Tangent contact

5.3.2.4.2 Secant contact at partially open switch tip or crossing nose

The worst case is encountered when the worn wheel hits the switch tip with a positive angle of attack and when the wheel is in contact with the corresponding stock rail (see Figure 13). There are two contact points:



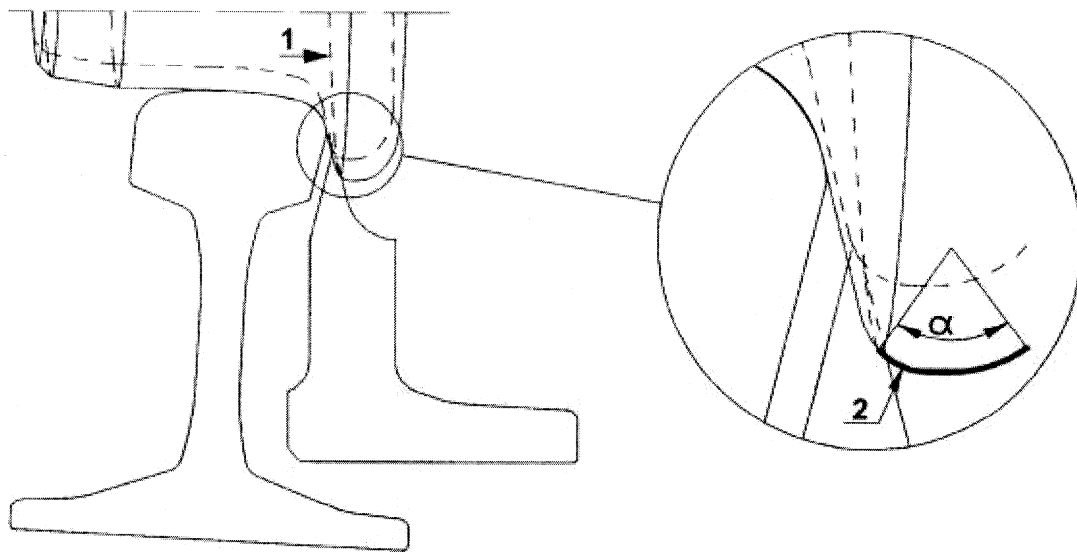
Key

- 1 PC1 with the switch tip at contact point 1
- 2 PC0 with the stock rail at contact point 2

Figure 13 — Secant contact

The contact angle in contact point *PC1* is to be compared with the limiting value of γ_A . The contact point should stay out of the danger zone of the wheel. In Figures 14 and 15 the danger zone is indicated.

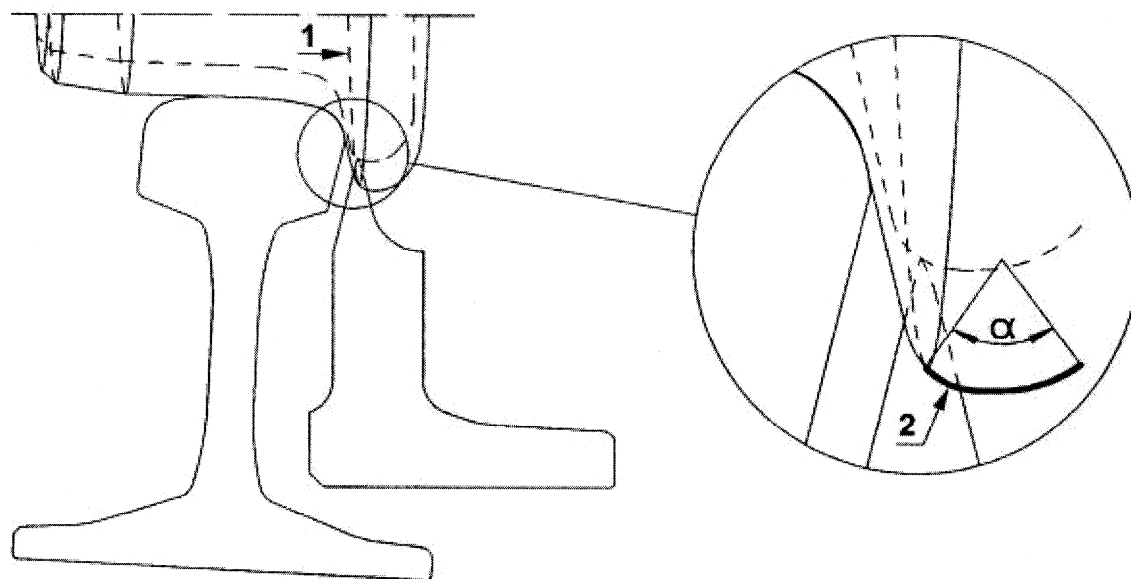
Figure 14 represents a safe situation. Figure 15 represents a situation that is potentially dangerous.



Key

- 1 ellipse γ_A
- 2 contact danger zone
- α angle of dangerous zone

Figure 14 — Safe secant contact



Key

- 1 ellipse γ_A
- 2 contact danger zone
- α angle of dangerous zone

Figure 15 — Dangerous secant contact

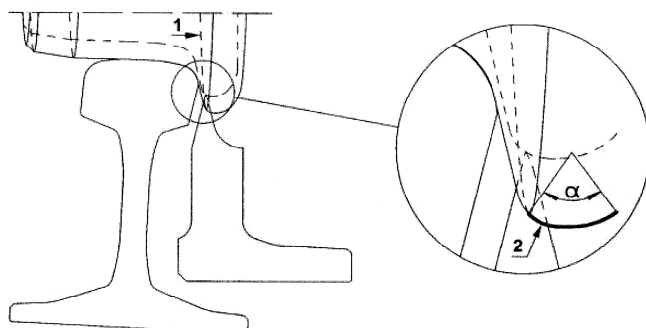
5.3.2.4.3 Secant contact at damaged switch tip (for information only)

This situation has been studied in UIC 716.

The worst case appears when a new wheel profile, lifted by 2 mm, encounters the tongue with a maximum angle of attack (including entry angle). This situation is illustrated in Figure 16 and 17.

Dimensions in millimetres

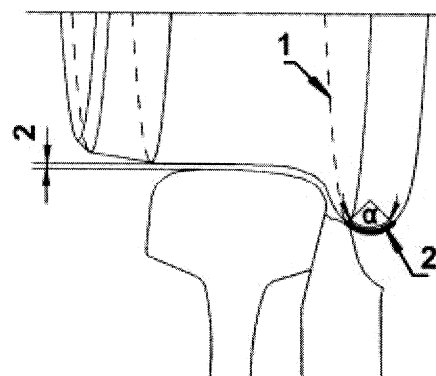
Dimensions in millimetres



Key

- 1 ellipse γ_A
- 2 contact danger zone
- α angle of dangerous zone

Figure 16 — Safe contact



Key

- 1 ellipse γ_A
- 2 contact danger zone
- α angle of dangerous zone

Figure 17 — Dangerous contact

The hazard does not occur when the contact angle is greater than the limiting value. The contact point from the damaged switch tip shall lay high enough not to touch the wheel in the danger zone.

This situation has no direct implications on switch and crossing design.

Figure 16 represents a safe situation. Figure 17 represents a potentially dangerous situation.

5.3.2.5 Limits

Limits shall be provided by the customer.

For the traffic with UIC-wheels, according to EN 13715 and UIC 510-2, the following limits shall be respected:

- maximum angle of attack $\leq 1^\circ$ (does not include switch entry angle);
- $q_R > 6,5$ mm;
- $\gamma_A \geq 40^\circ$ (corresponding to $Y/Q = 0,4$ and $\mu = 0,3$).

Customers or networks can request more stringent limits for economical, or maintenance reasons.

5.3.3 Output

5.3.3.1 Functional and Safety Dimensions (FSD)

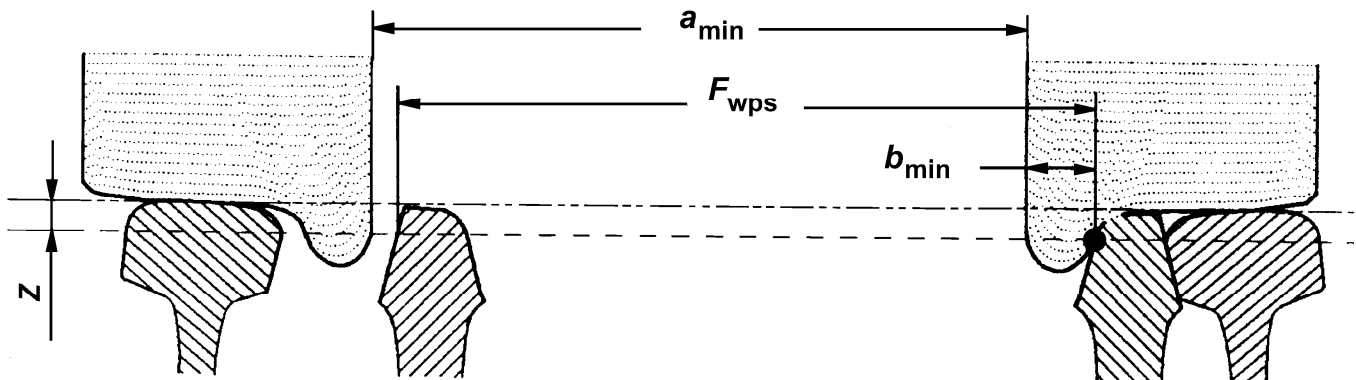
5.3.3.1.1 Switch panel

5.3.3.1.1.1 Free wheel passage in switches F_{WPS}

The passing wheel shall not be able to strike the open switch rail. Over the whole length of the switch the back of the wheel shall not be able to strike the back of the switch rail.

This situation is represented in Figure 18. The following equation shall be respected.

$$F_{WPS} < a_{\min} + b_{\min} \quad (3)$$



Key

$a_{\min}$	minimum value of wheel back-to-back
$b_{\min}$	minimum flange width
F_{WPS}	free wheel passage in switches
Z	stock rail machining reference plane

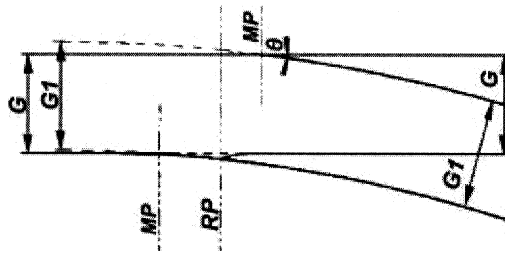
Figure 18 — Free wheel passage in switches

In order to be able to respect this value during operation the design value shall be agreed between customer and supplier, taking into account tolerances for:

- lateral wear on switch rail;
- vertical wear on stock rail;
- gap between switch rail and associated stock rail;
- workshop tolerances;
- gauge widening;
- geometrical aspects such as inclined switch back machining;
- etc.

5.3.3.1.1.2 Entry angle

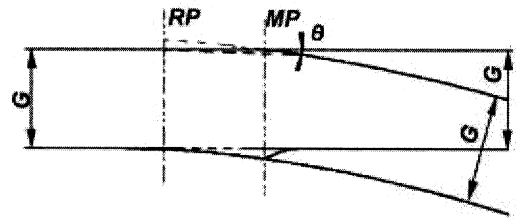
Important entry angles occur when gauge widening is applied to the branch line, i.e. in case of tight curves (see Figure 19). A similar situation may occur when switch rails are shortened (see Figure 20).



Key

G gauge
G1 gauge widening
MP mathematical point of switch
RP real point of switch
 θ switch entry angle

Figure 19 — Tight curve design



Key

G gauge
MP mathematical point of switch
RP real point of switch
 θ switch entry angle

Figure 20 — Shortened switch design

Both situations may lead to a greater angle of attack, also depending on the track characteristics in front of the switch. The limiting angle of attack shall be determined by the customer.

For UIC-wheels corresponding to UIC 510-2, the limits given in the first column of Table 1 apply, depending on the maximum speed of the branch line. For tracks, designed in accordance to prEN 13803-2, this leads to the limits given in the second column.

Table 1 — Maximum angle of attack for UIC-wheels

Speed	Maximum angle of attack	Maximum entry angle (prEN 13803-2)
≤ 40 km/h	2°	1°
≤ 100 km/h	$1,41(6)^\circ$	$0,41(6)^\circ$
> 100 km/h	Reserved	Reserved

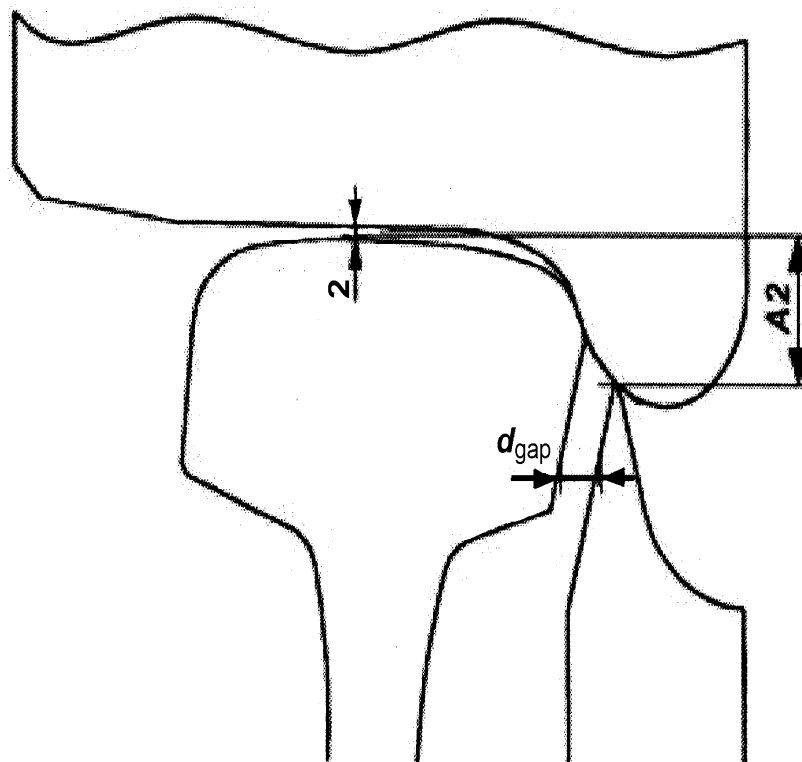
The actual chosen value shall be agreed between customer and supplier taking into account:

- requested comfort level;
- worst situation that may occur in the adjacent track;
- available turnout length;
- maintenance tolerance (i.e. grinding limits of the switch rail);
- acceptable mechanical resistance;
- etc.

5.3.3.1.1.3 Switch point relief A2

The switch point relief at the switch tip shall be determined such that no contact occurs in the wheel danger zone. The worst case occurs with new wheel flanges and the switch opened at its limit d_{gap} (accepted by the detection system). A 2 mm wheel lift will be taken into account. See also Figure 21.

Dimensions in millimetres



Key

- A2 switch point relief
 d_{gap} switch rail opening

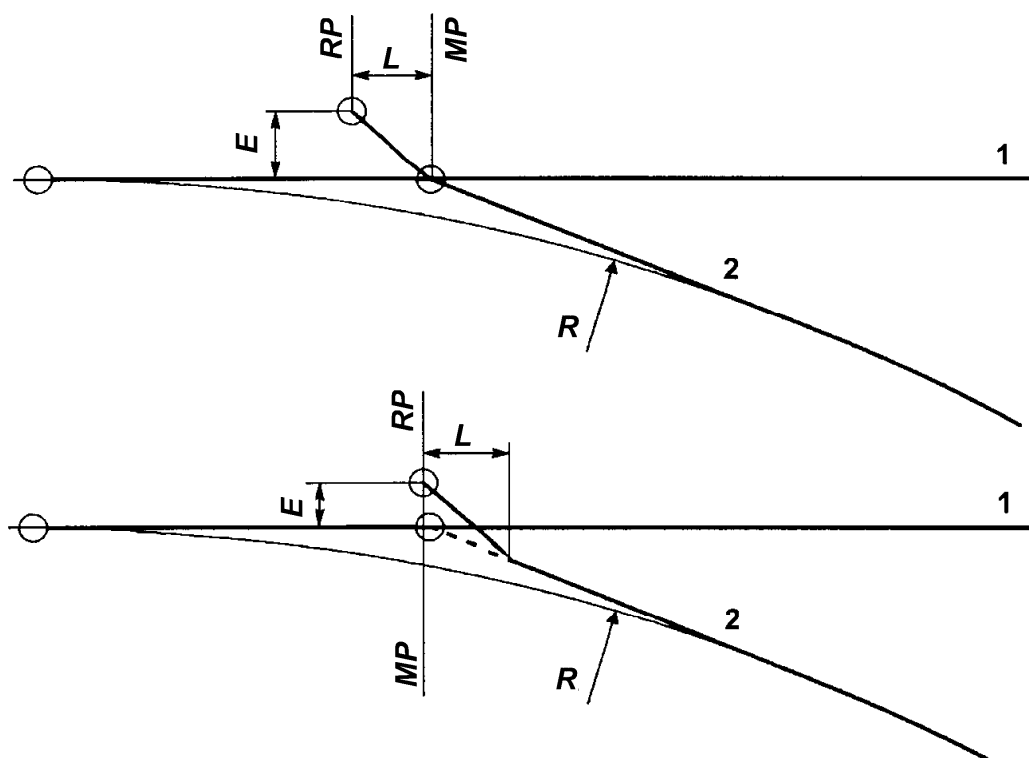
Figure 21 — Switch point relief

For wheels according EN 13715, the maximum switch point relief shall be no bigger than 25 mm.

The actual value shall be determined taking into account:

- workshop tolerances;
- lateral stock rail wear;
- detection system;
- etc.

5.3.3.1.1.4 Lateral point retraction



Key

- | | | | |
|----------|---------------------------------|-----------|------------------------------|
| 1 | stock rail | <i>MP</i> | mathematical point of switch |
| 2 | switch rail | <i>RP</i> | real point of switch |
| <i>L</i> | length of side relief machining | <i>R</i> | branch line radius |
| <i>E</i> | point retraction | | |

Figure 22 — Lateral point retraction

In order to prohibit the wheel pushing the switch toe aside, the switch toe shall be sufficiently protected by its corresponding stock rail. This will lead to a lateral point retraction, as shown in Figure 22 (see also 5.3.2.4.). The worst situation will appear with worn wheels (small flange sharpness q_R) with high angle of attack.

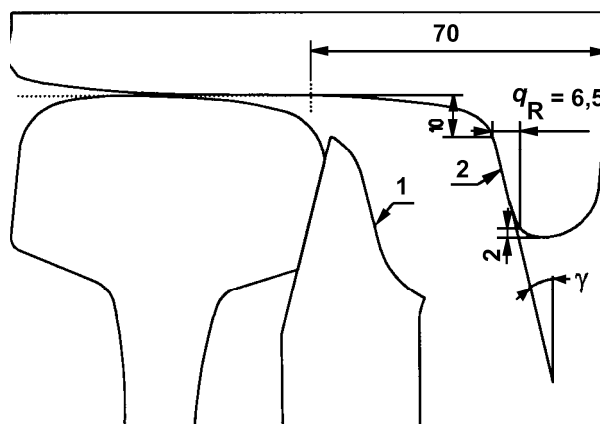
The length L and the value of the retraction E shall be agreed between customer and supplier, taking into account:

- the workshop tolerances;
- the lateral stock rail wear;
- the detection system used (maximum gap at switch point d_{toe} – see EN 13232-4);
- maintenance prescriptions;
- etc.

For vehicles in accordance to UIC 510-2, the point retraction E shall be at least 3 mm for turnouts, designed for 100 km/h or more in branch line. This point retraction length L shall be at least 200 mm.

5.3.3.1.1.5 Lateral point machining

Dimensions in millimetres



Key

- 1 switch rail running face
- 2 flange running face
- γ flange angle
- q_R flange sharpness

Figure 23 — Lateral point machining

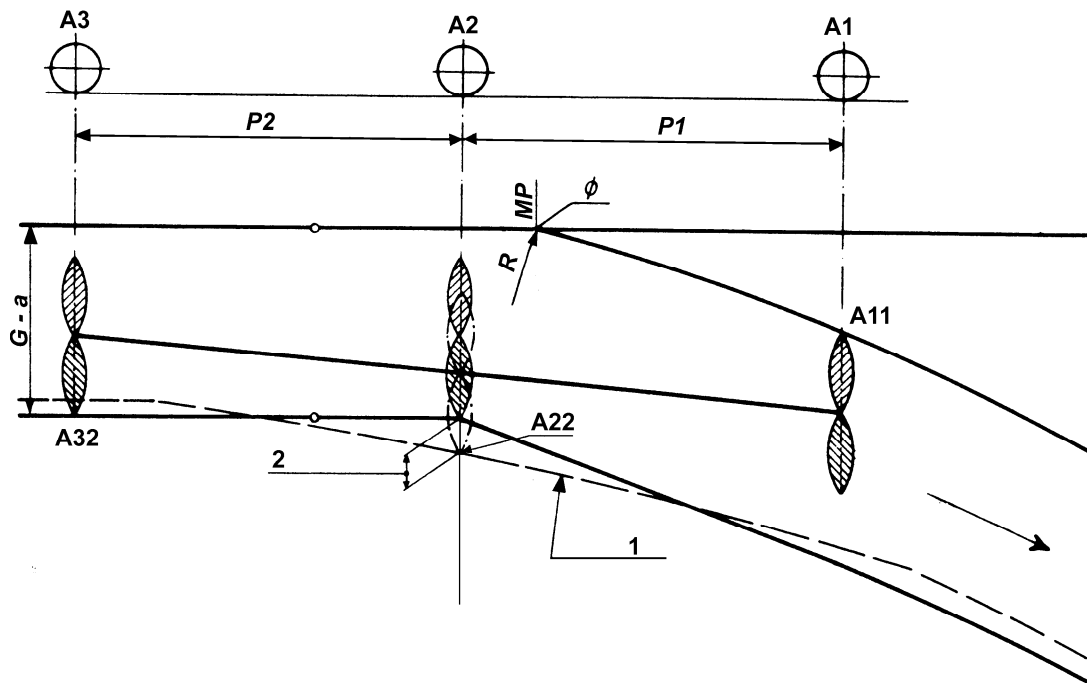
The lateral point machining shall be chosen such that the wheel can't climb up the switch tip. The sharp wheel flange shall be considered for the worst situation.

For wheels in accordance with UIC 510-2, the minimum flange sharpness q_R is 6,5 mm which corresponds to an angle $\gamma = 14^\circ$. This corresponds to the maximum angle to which the switch toe may be machined laterally.

The actual value shall be determined between customer and supplier, taking into account:

- workshop tolerances;
- maintenance prescriptions;
- etc.

5.3.3.1.1.6 Gauge in diverging track – vehicle with 3 axles inscription



Key

A1	leading axle	P1	distance between axle 1 and 2
A2	middle axle	P2	distance between axle 2 and 3
A3	trailing axle	ϕ	entry angle
1	virtual trajectory of axle 2	2	clearance of middle axle
A11	contact axle 1/	A22	virtual contact axle 2/
A32	contact axle 3/	R	branch line radius

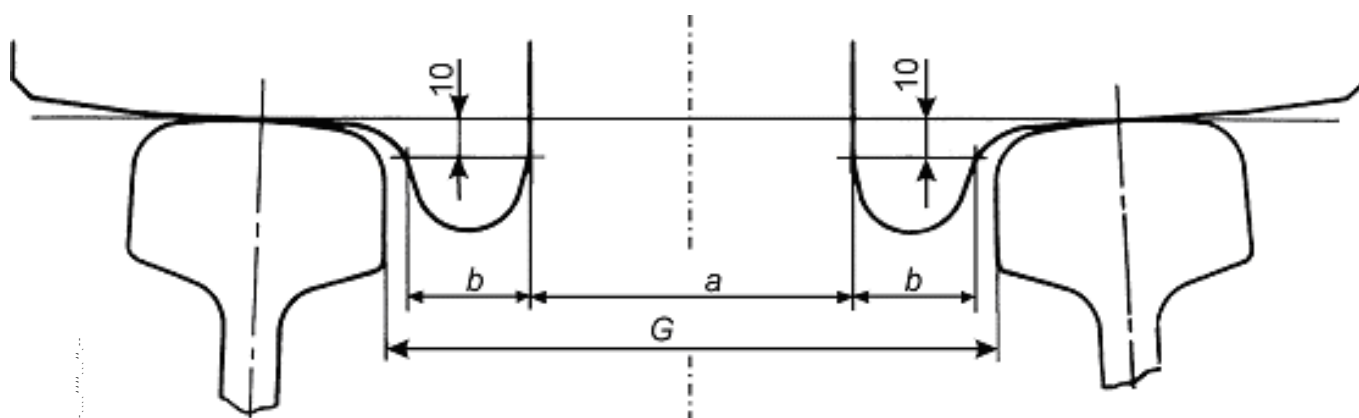
Figure 24 — Vehicle with three axles inscription

In order to permit three axle vehicles or bogies to run through the branch line, gauge widening may be required.

The leading axle of a three axle vehicle or bogie enters the branch line with the leading axle in contact to the outside rail, the trailing axle being in contact with the inside rail. This situation is given in Figure 24, representing the axles only by the wheel flanges, without wheel back to back (see Figure 25).

The middle axle normally has a larger track clearance than the outer axles, either because of smaller flange widths or larger lateral axle clearances in the suspensions. In order to guarantee free passage, the track clearance shall be large enough for this middle axle to permit its passage without forcing the vehicle to move laterally.

Dimensions in millimetres



Key

- a wheel back-to-back
- b flange width
- G track gauge

Figure 25 — Schematic axle representation

5.3.3.1.2 Closure panel

No special requirements are to be applied.

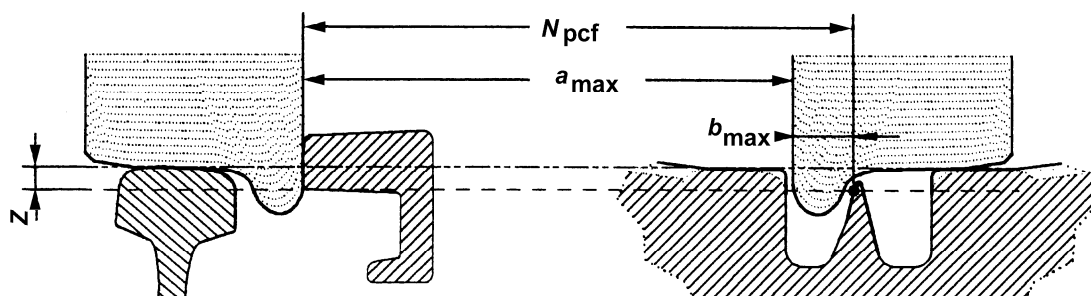
5.3.3.1.3 Common crossing panel

5.3.3.1.3.1 Fixed nose protection N_{pcf}

The wheel shall be kept away from the crossing nose by the check rail, when running through the crossing panel.

This situation is represented in Figure 26. The following equation can be derived:

$$N_{pcf} \geq a_{\max} + b_{\max} \quad (4)$$



Key

- $a_{\max}$ maximum value of wheel back-to-back
- $b_{\max}$ maximum flange width
- N_{pcf} nose protection in crossing
- Z gauge reference plane

Figure 26 — Nose protection in fixed common crossing

This dimension is taken between the active side of the check rail and the running edge of the nose at the real point (RP).

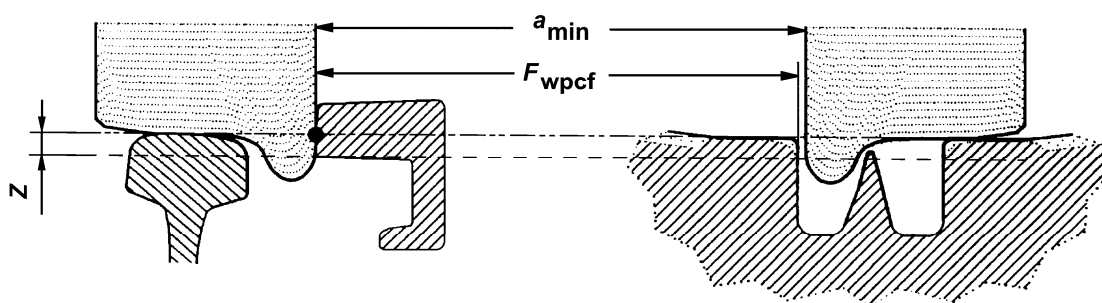
The nominal design value for N_{pcf} will be agreed between customer and supplier, taking into account:

- workshop tolerances;
- tolerances in operation for vertical wear in conjunction with the point side inclination;
- actual point retraction (if applicable);
- maximum permitted wear at check rail;
- etc.

5.3.3.1.3.2 Free wheel passage F_{wpcf}

The check and wing rail shall not be positioned so as to cause wheel trapping on the back-to-back dimension. This situation has been represented in Figure 27. The following equation can be derived:

$$F_{wpcf} < a_{\min} \quad (5)$$



Key

$a_{\min}$	minimum value of wheel back-to-back
F_{wpcf}	free wheel passage
Z	gauge reference plane

Figure 27 — Free wheel passage in fixed common crossing

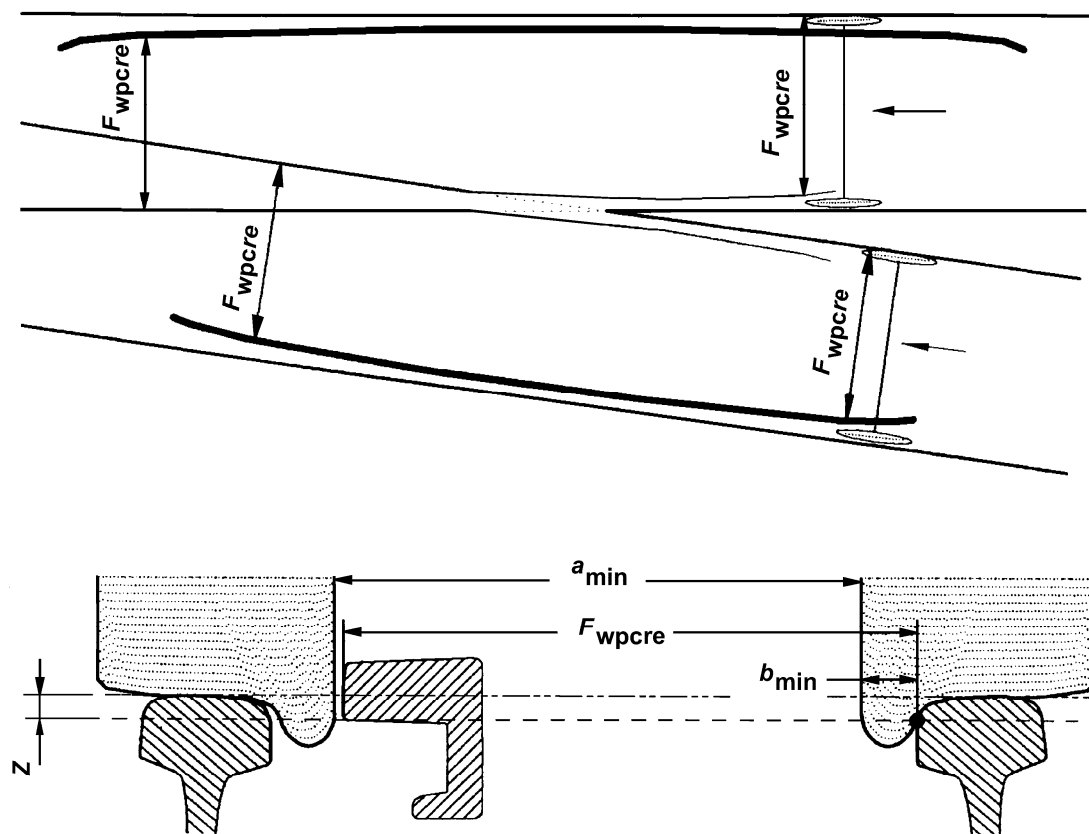
This dimension is taken between the active check rail side and the wing rail at the running edge.

The nominal design value for F_{wpcf} shall be agreed between customer and supplier, taking into account the tolerances on check rail position after installation.

5.3.3.1.3.3 Free wheel passage at check rail entry F_{wpcre}

The check rail shall only become active after the check rail entry point. This situation is represented in Figure 28. Following equation can be derived:

$$F_{wpcre} < a_{\min} + b_{\min} \quad (6)$$



Key

a_{min}	minimum value of wheel back-to-back
b_{min}	minimum flange width
F_{wpcr}	free wheel passage in check rail entry
Z	gauge reference plane

Figure 28 — Free wheel passage at check rail entry

This dimension is taken between the active side of the check rail and the running edge of the opposite rail.

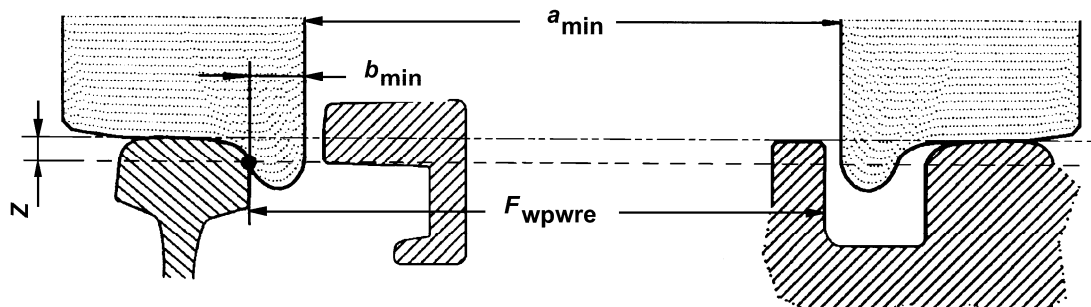
The nominal value shall be agreed between customer and supplier taking into account:

- workshop tolerances;
- maximum values for lateral rail wear;
- installation tolerances for check rail position;
- gauge widening;
- etc.

5.3.3.1.3.4 Free wheel passage at wing rail entry F_{wpwre}

The wing rail entry shall only become active after the wing rail entry point. This situation is represented in Figure 29. Following equation can be derived:

$$F_{wpwre} < a_{min} + b_{min} \quad (7)$$



Key

a_{min}	minimum value of wheel back-to-back
b_{min}	minimum flange width
F_{wpwre}	free wheel passage at wing rail entry
Z	gauge reference plane

Figure 29 — Free wheel passage at wing rail entry

This dimension is taken between the active side of the wing rail and the running edge of the opposite rail.

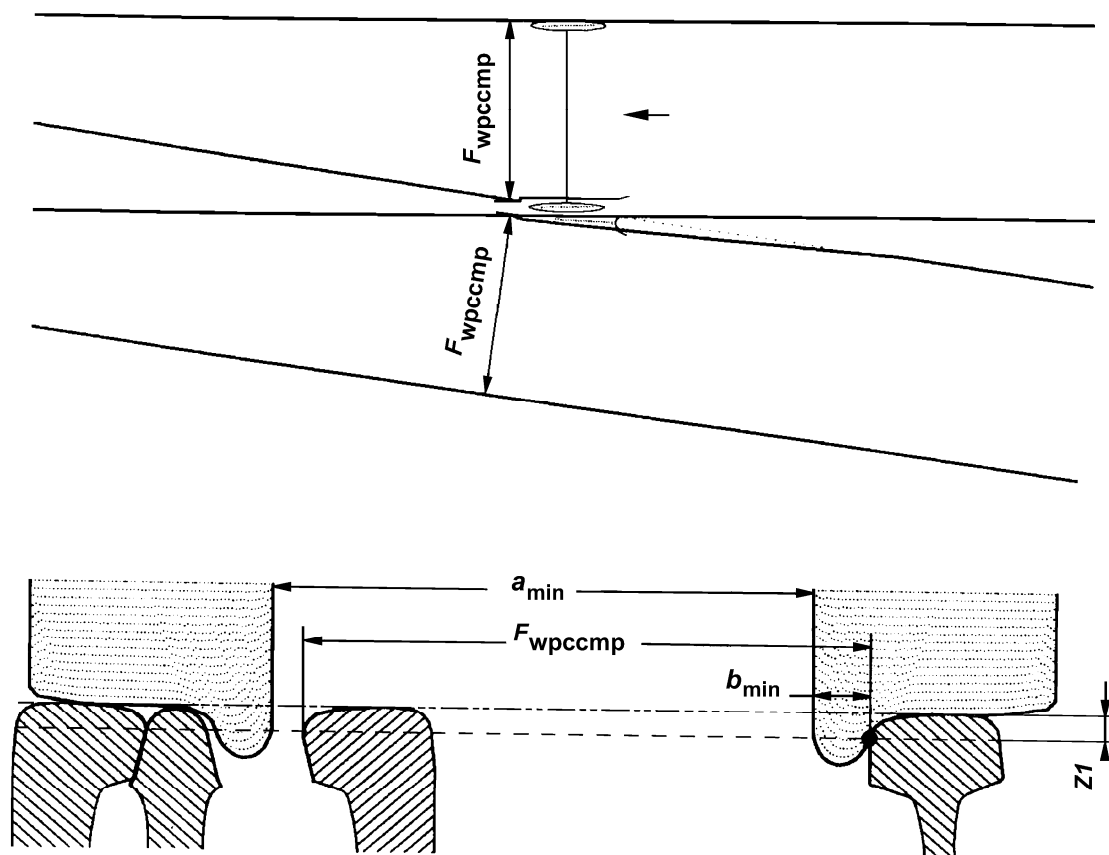
The nominal value shall be agreed between customer and supplier taking into account:

- workshop tolerances;
- maximum values for lateral rail wear;
- crossing production tolerances;
- etc.

A similar situation applies to crossings with moveable parts (F_{wpccmp}). See also Figure 30:

$$F_{wpccmp} < a_{min} + b_{min}$$

(8)



Key

a_{min}	minimum value of wheel back-to-back
b_{min}	minimum flange width
F_{wpccmp}	free wheel passage in crossing with moveable parts
Z	gauge reference plane

Figure 30 — Free wheel passage in crossings with moveable parts

5.3.3.1.3.5 Minimum flangeway depth h_{fw}

The minimum flangeway depth h_{fw} shall be sufficient to avoid contact with the wheel flange.

The minimum value shall be agreed between customer and supplier taking into account:

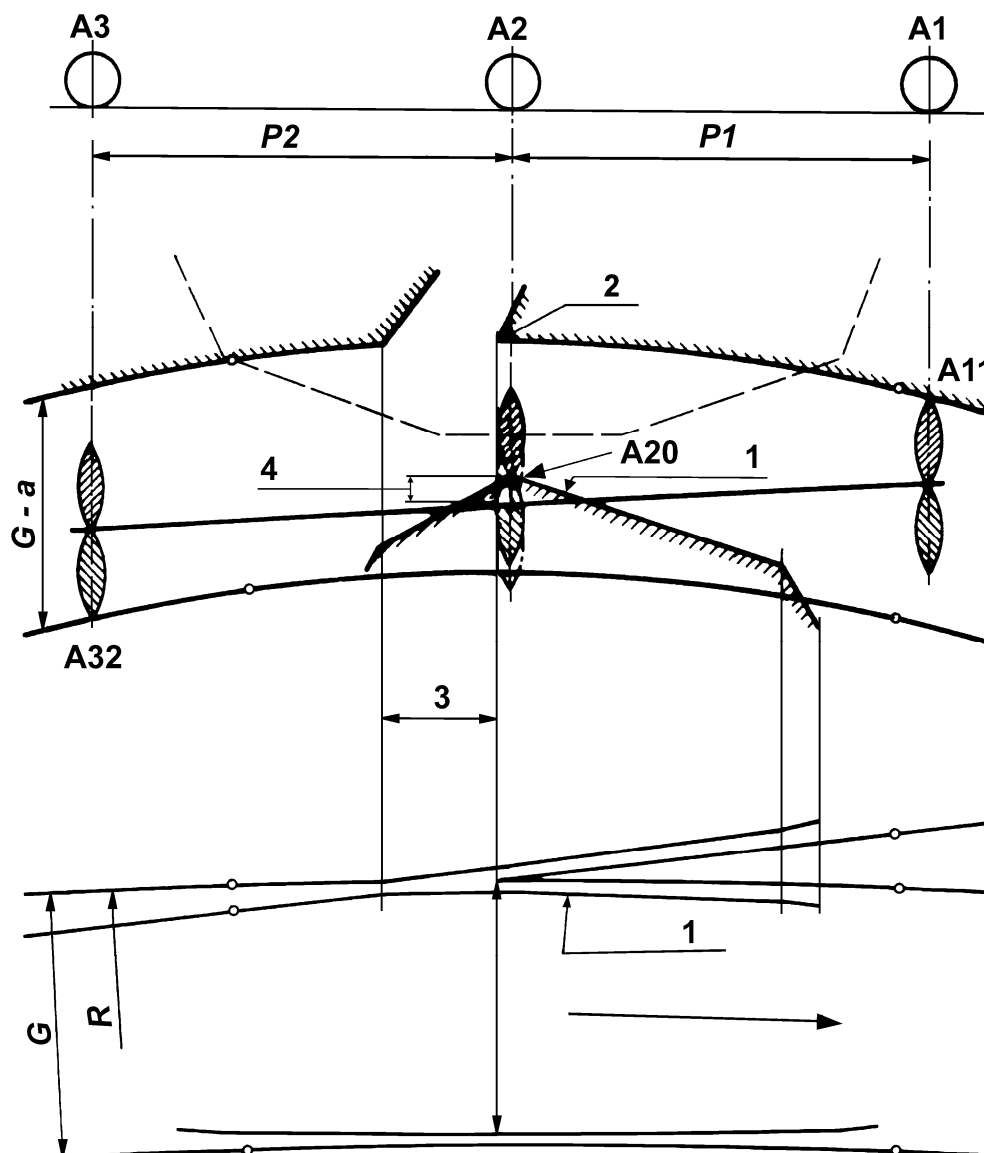
- maximum vertical wear;
- margin for ballast particles and other objects trapped in the flangeway;
- maximum effective flange depth h_{fl} .

5.3.3.1.3.6 Flangeway width in diverging track

In order to permit three axle vehicles or bogies to run through the branch line, flangeway width calculation may be required.

The leading axle of a three axle vehicle or bogie runs through the branch line with the leading axle in contact to the outside rail, the trailing axle being in contact with the inside rail. This situation is given in Figure 31, representing the axles only by the wheel flanges, without wheel back to back (see Figure 25).

The middle axle normally has a larger track clearance than the outer axles, either because of smaller flange widths or larger lateral axle clearances in the suspensions. In order to guarantee free passage, the flangeway width shall be large enough for this middle axis to permit its passage without forcing the vehicle to move laterally.



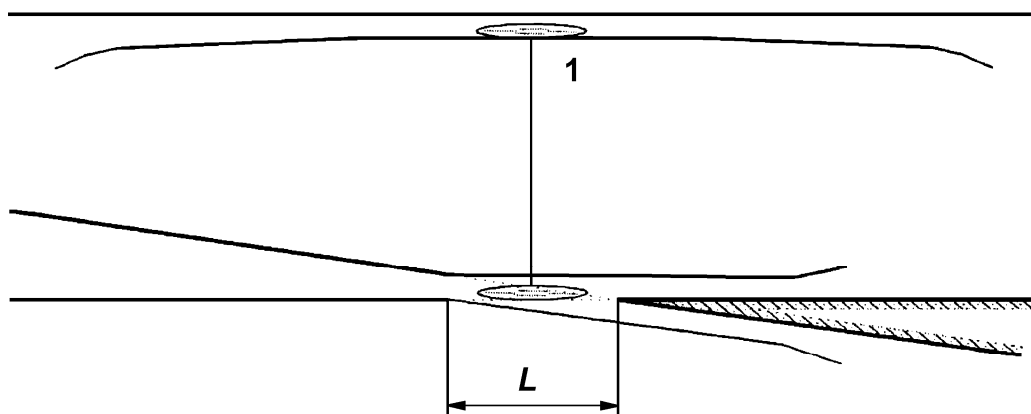
Key

A1	leading axle	P1	distance between axle 1 and 2
A2	middle axle	P2	distance between axle 2 and 3
A3	trailing axle	R	branch line radius
1	wing rail	2	theoretical intersection point
3	crossing gap	4	clearance of middle axle
A11	contact axle 1/	A20	contact axle 2/ wing rail....
A32	contact axle 3/	G	gauge
		a	wheel back-to-back

Figure 31 — Flangeway width in diverting track

5.3.3.1.3.7 Parallel check rail length

The check rail shall be effective over the whole length where the crossing is not giving sufficient guidance to the wheelset. This length L is illustrated in Figure 32.



Key

- 1 wheelset
- L unguided length (or crossing gap)

Figure 32 — Parallel check rail length

This effective length is defined by the parallel length of the check rail and the effective length of the wheel. The latter depends on the height of the check rail and the minimum wheel radius.

5.3.3.1.3.8 Check rail and raised check rail

The check rail shall always be above or at running plane level. The height shall be chosen according the requested effective wheel length.

The check rail shall never enter the relevant vehicle gauge.

The nominal value shall always stay outside the obstacle gauge.

The actual nominal value shall be agreed between customer and supplier, taking into account:

- workshop tolerances;
- maximum vertical rail wear;
- maximum burs on check rail;
- minimum vertical track radius;
- etc.

For vehicles according UIC 505-1, the maximum height of the check rail above the running surface in operation is 80 mm. For networks, working according UIC 505-4, the nominal value shall be not larger than 60 mm.

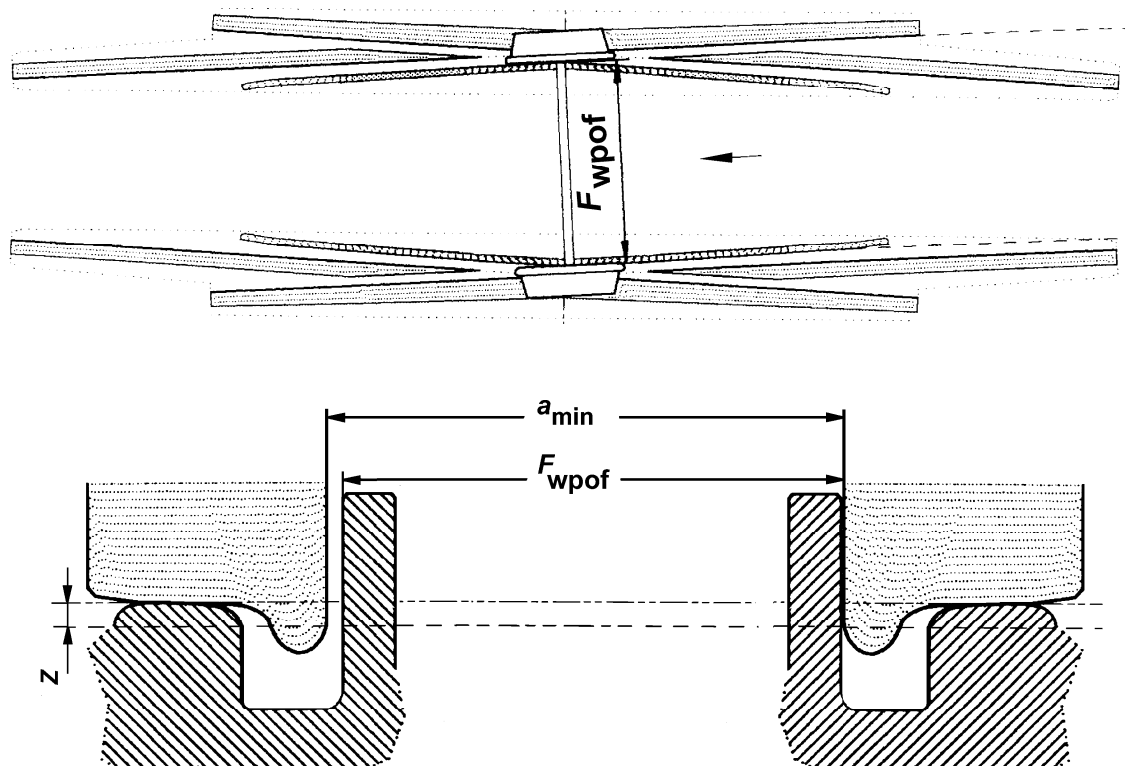
5.3.3.1.4 Obtuse crossing panel

5.3.3.1.4.1 Free wheel passage F_{wpof}

The two check rails shall not be positioned so as to cause wheel trapping on the back-to-back dimension. This situation has been represented in Figure 33. The following equation can be derived:

$$F_{wpof} < a_{min}$$

(9)



Key

a_{min}	minimum value of wheel back-to-back
F_{wpof}	free wheel passage in obtuse crossing
Z	gauge reference plane

Figure 33 — Free wheel passage in obtuse crossing

This dimension is taken between the parallel active sides of the check rails and on both branches.

The nominal design value shall be agreed between customer and supplier, taking into account:

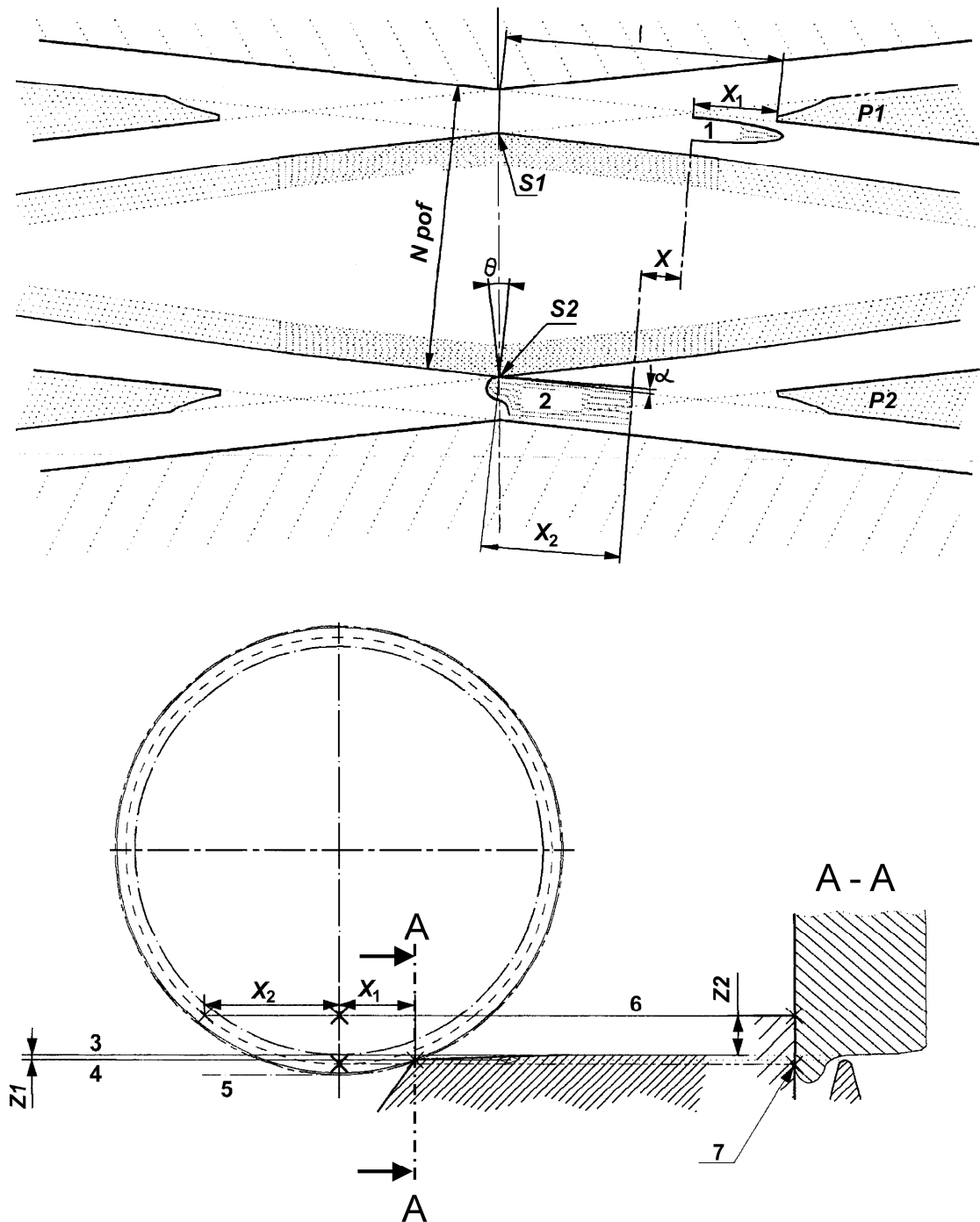
- fabrication tolerances;
- gauge widening;
- etc.

5.3.3.1.4.2 Unguided length

In obtuse crossings the check rail cannot be extended to opposite position of the crossing point, due to flangeway of the other branch line.

The unguided zone is determined as the distance between the check rail knuckle and the actual point (*RP*) of the according branch line, measured parallel to this branch line axis.

The unguided length is the length of the unguided zone, shortened by the effective length of the wheel. This effective length ($X_1 + X_2$) depends on the radius of the wheel and the height of the check rail as illustrated in Figure 34.



Key

1	wheel 1	$P1, P2$	point 1, 2
2	wheel 2	$S1, S2$	check rail knuckle
3	running surface	$Z1$	point lowering
4	point	$Z2$	height of check rail elevation above running table
5	wheel top	θ	crossing angle
6	check rail	α	truck swing
7	contact point of check rail	l	running line interruption
		X	unguided length

Figure 34 — Unguided length

The permissible unguided length X depends on the form of the point and the running conditions throughout the obtuse crossing.

For vehicles in accordance with UIC, experiments have shown that wheels with 330 mm radius can pass safely over an obtuse crossing with 1 435 mm gauge and a minimum tangent 0,11 or 1 in 9 when a minimum check rail height of 45 mm above running surface is guaranteed. The maximum angle of attack that may occur for these vehicles is given in Annex D.

5.3.3.1.4.3 Check rail and raised check rail

The check rail will always be above or at running plane level. The height shall be chosen according to the requested effective wheel length.

This effective wheel length is needed to assure guidance through the unguided length.

The check rail shall never enter the relevant vehicle gauge.

The nominal value shall always stay outside the obstacle gauge.

The actual nominal value shall be agreed between customer and supplier, taking into account:

- workshop tolerances;
- maximum vertical rail wear;
- maximum burs on check rail;
- minimum vertical track radius;
- etc.

For vehicles in accordance with UIC 505-1, the maximum check rail height above running rail in operation is 80 mm. For networks, working according UIC 505-4, the nominal value shall be no larger than 60 mm.

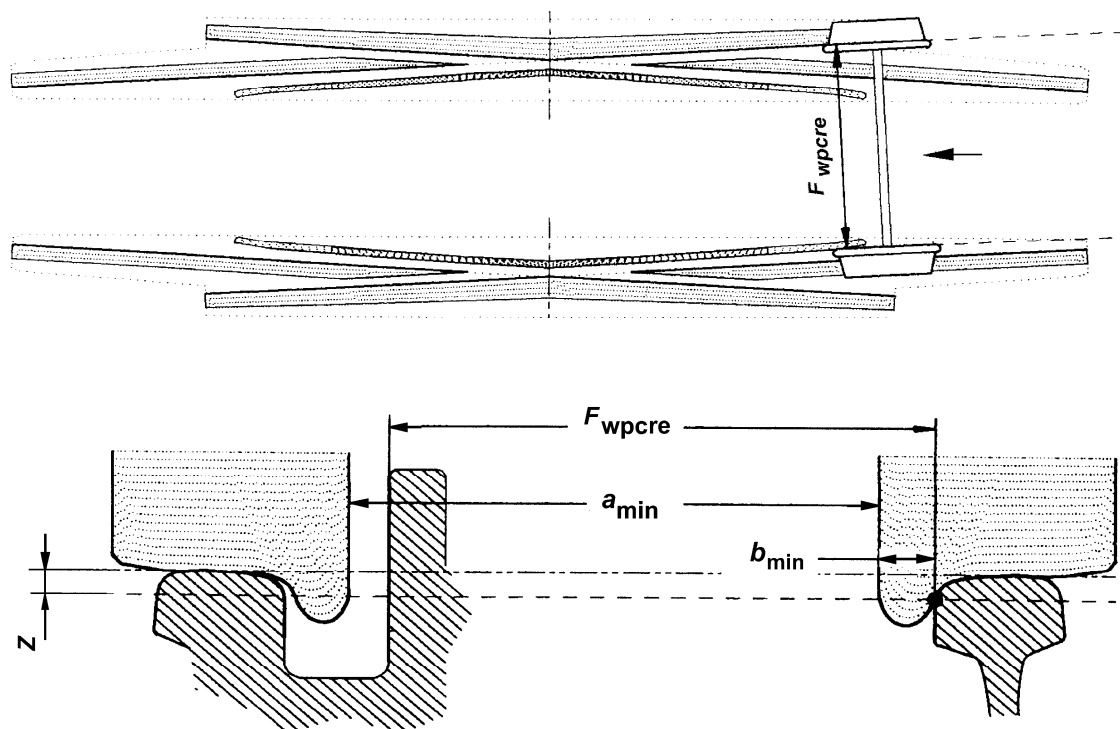
For vehicles in accordance with UIC, the nominal check rail height shall never be smaller than 45 mm in obtuse crossing having an angle of more than tangent 0,11 or 1 in 9.

The same rules apply as in a common crossings panel.

5.3.3.1.4.4 Free wheel passage at check rail entry

The check rail shall only become active after the check rail entry point. This situation is represented in Figure 35. Following equation can be derived:

$$F_{\text{wpcr}} < a_{\text{min}} + b_{\text{min}} \quad (10)$$



Key

$a_{\min}$	minimum value of wheel back-to-back
$b_{\min}$	minimum flange width
F_{wpcr}	free wheel passage at check rail entry
Z	gauge reference plane

Figure 35 — Free wheel passage at check rail entry

This dimension is taken between the active side of the check rail and the running edge of the opposite rail.

The nominal value shall be agreed between customer and supplier taking into account:

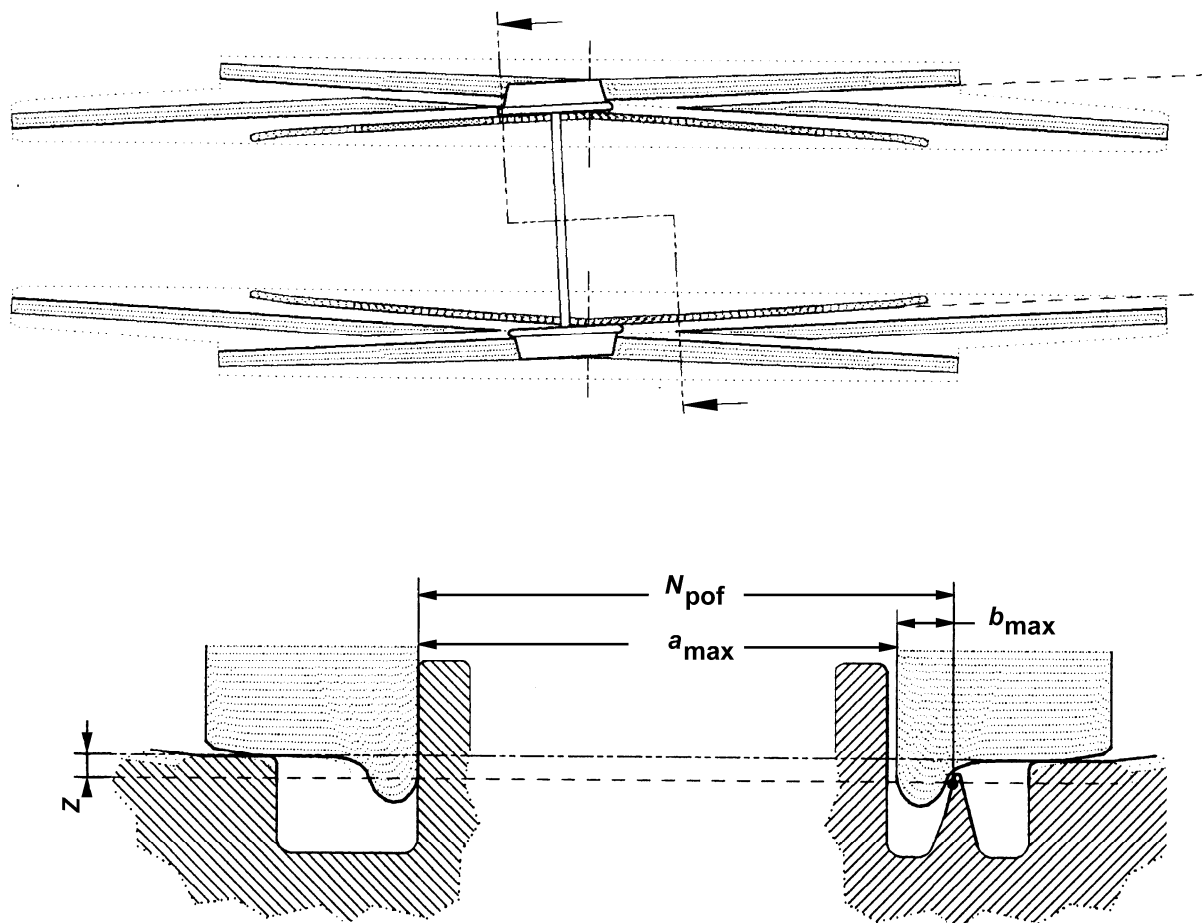
- workshop tolerances;
- maximum values for lateral rail wear;
- installation tolerances for check rail position;
- etc.

5.3.3.1.4.5 Nose protection N_{pof}

The wheel shall be kept away from the crossing nose by the check rail, when running through the crossing panel.

This situation is represented in Figure 36. The following equation can be derived:

$$N_{pof} \geq a_{\max} + b_{\max} \quad (11)$$



Key

$a_{\max}$	maximum value of wheel back-to-back
$b_{\max}$	maximum flange width
N_{pof}	nose protection in crossing
Z	gauge reference plane

Figure 36 — Nose protection in obtuse crossing

This dimension is taken between the running edge at the crossing point (*RP*) and the active side of the parallel check rail.

The nominal design value for N_{pof} shall be agreed between customer and supplier, taking into account:

- workshop tolerances;
- tolerances in operation for vertical wear in conjunction with the point side inclination;
- actual point retraction (if applicable);
- maximum permitted wear at check rail;
- etc.

5.3.3.1.5 General items (may occur in plain line or outside S&C)

5.3.3.1.5.1 Check rail and wing rail entry flare

The minimum entry flare depends on the speed of the vehicle that runs over this relevant line.

The actual value shall be agreed between customer and supplier.

5.3.3.1.5.2 Flangeway width – wheel trapping

In certain conditions (tight curves) one may be obliged to put check rails in order to eliminate the risk of climbing wheels.

In order to ensure wheel trapping does not occur in the check rail, a minimum flangeway of 40 mm shall be respected.

5.3.3.2 Additional requirements

The functional and safety dimensions are necessary but not sufficient to guarantee safe passage of vehicles through the S&C. Therefore proof of the following checks shall always be performed on every new design.

5.3.3.2.1 Guidance

The maximum angle of attack shall always be checked, taking into account the worst track condition that may occur.

5.3.3.2.2 Load transfer

The load transition zone for all types of used wheels shall be determined.

The minimum bearing width shall be determined and approved by the customer.

5.3.3.2.3 Insufficient wheel support or guidance

When insufficient wheel support or guidance is encountered, alternatives shall be applied.

6 Main constructional design (step 2)

6.1 Inputs

The customer shall give sufficient information to permit the supplier to perform the detailed design. The following information shall always be delivered, characterising the use of the S&C:

- axle load;
- gross tonnage;
- train speed;
- use in continuously welded track;
- use and positions of insulated joints or other signalling system equipment;
- standard track subgrade conditions.

Based on this information several technical choices will have to be made defining:

- rail section;
- switch rail section;
- rail inclination;
- bearer type;
- bearer spacing (minimum, nominal and maximum value);
- rail fastening system.

In addition several options are open for the customer:

- main switch design;
- crossing type;
- baseplate type;
- insulation;
- switch heating system (if required);
- baseplate fastening system.

6.2 Structural requirements

6.2.1 General

The complexity of the system prevents the laying down of general rules for this design.

For existing designs, the supplier shall demonstrate through similar applications and/or relevant references.

For new designs, the designer shall demonstrate the fitness for use through calculations, laboratory and/or track testing, according to the customer's regulations.

6.2.2 General requirements

The track system shall be suitably designed to ensure the stability of the track whilst under traffic.

Horizontal and vertical vehicle loads shall be properly transferred to the sub-grade.

Thermal forces shall be properly transferred through the S&C into the adjacent track sections as well as the sub-grade.

Obstacle gauge and especially flangeway depth shall be respected in accordance with UIC 505-4 or the relevant EN.

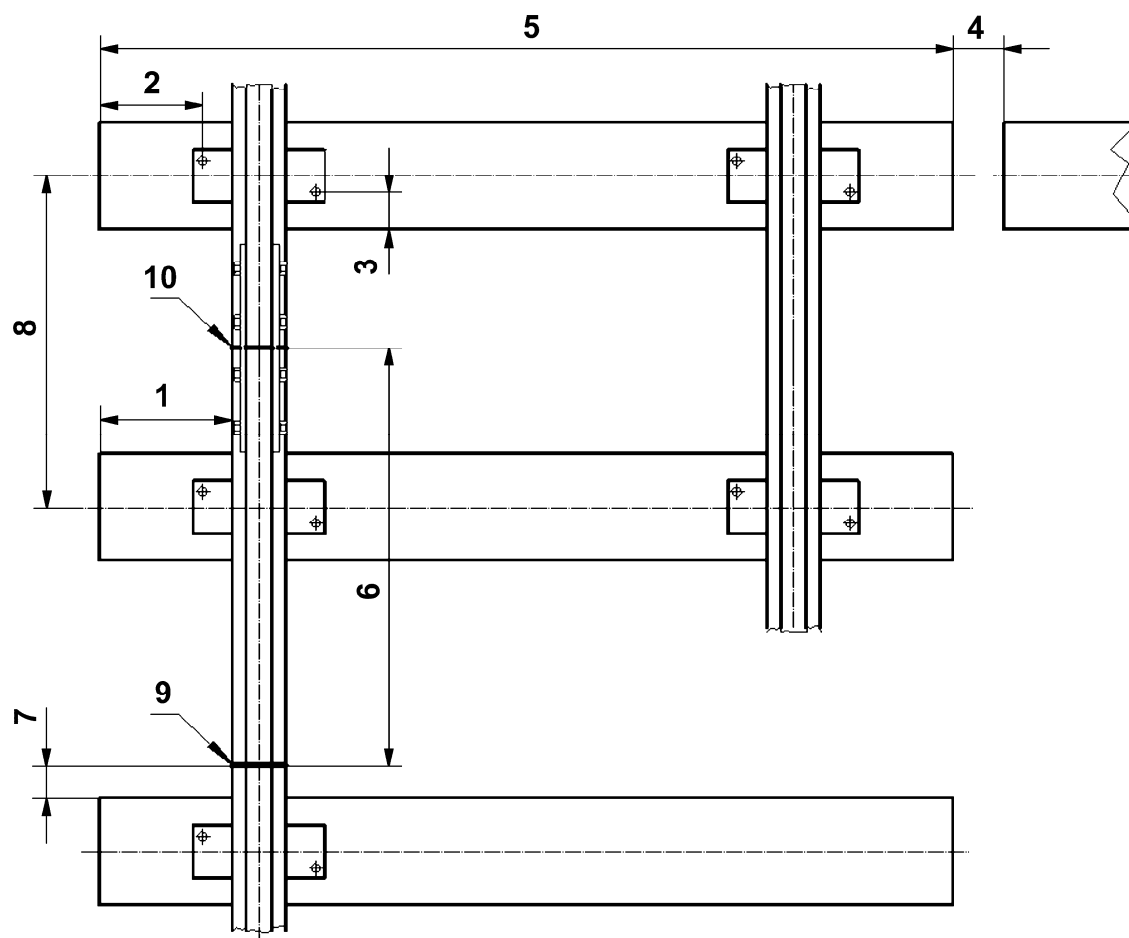
6.2.3 Specific requirements

The following specific requirements shall be respected during design:

- distance between rail foot and bearer end (nominal, minimum and maximum);
- minimum distance between screw axis and bearer end and side;
- minimum distance between bearer ends respectively;

- bearer length (maximum and minimum);
- nominal bearer spacing at joints;
- minimum distance between joints and/or welds;
- maximum rail section length;
- minimum number of fastenings between unfastened rail section (i.e. switch) and weld or joint;
- minimum distance between weld position and bearer;
- gauge necessary for fastening machines equipment.

Several of these dimensions are represented on Figure 37.



Key

- 1 distance between rail foot and bearer end
- 2 minimum distance between screw axis and bearer end
- 3 minimum distance between screw axis and bearer side
- 4 minimum distance between bearer ends respectively
- 5 bearer length
- 6 minimum distance between joints and/or weldings
- 7 minimum distance between weld position and bearer
- 8 bearer spacing
- 9 welding
- 10 joint

Figure 37 — Specific requirements

6.2.4 Other requirements

Additional requirements may be given by the customer taking into account transport, handling and maintenance of the S&C's or their components. In this case, the customer shall provide the designer with all necessary information on the installation and maintenance machinery used in conjunction with the S&C.

In case of special prevailing environmental conditions, the customer shall give all necessary information to permit the supplier to adapt his design.

6.3 Actuation, locking and detection design

The design of the actuation, locking and detection system is not dealt with by this European Standard. As these systems have to work in tight conjunction with the S&C, the design shall be performed in parallel. EN 13232-4 defines the requirements for the conformity checking of the ALD-system.

The necessary inputs from the S&C are determined in EN 13232-4. A list summarising all information is given in A.3.

The geometrical design process is schematically given in Figure A.3.

The tests for conformity checking are given in EN 13232-4.

The conceptual ALD-design shall result in an ALD-layout-plan.

6.4 Output – main construction documents

The detailed design shall be incorporated into the “main construction plans and/or documents”. These shall contain the following details:

6.4.1 Geometry

- setting out diagram;
- track gauge;
- geometry (curvature);
- entry angle;
- type of geometrical form;
- detailed switch geometry (at the switch toe);
- detailed crossing geometry;
- detailed check rail geometry (entry angle, parallel length, ...).

6.4.2 Guidance

- crossing nose protection;
- flangeway;
- switch free wheel passage.

6.4.3 Actuation

- toe opening at drive position;
- throwing force (F_a);
- ALD-layout.

6.4.4 Constructional

- overall length;
- construction length of switch/stock rail;
- construction length of crossing (including wing rail, ...);
- construction length of check rail (including entry lengths);
- bearer positions.

6.4.5 Information lists

In addition the following information shall be supplied:

- rail section;
- rail inclination;
- fastenings;
- speed;
- axle loads;
- gross tonnage (annual or daily).

7 Detailed component design (step 3)

7.1 Switches

The inputs and rules for the design of half sets of switches and crossings are given in EN 13232-5. The designer shall take into account all rules given in Clause 5 of this European Standard and especially the functional and safety dimensions, determined according to 5.3.3.1 and Annex A.

All options given in the standard, mentioned above shall be agreed between customer and supplier.

All inputs and outputs are summarised in A.4.

7.2 Crossings

The inputs and rules for the design of crossings are given in EN 13232-6 for fixed crossings and EN 13232-7 for crossings with moveable parts. The designer shall take into account all rules given in Clause 5 of this European Standard and especially the functional and safety dimensions, determined according to 5.3.3.1 and Annex C.

All options given in the standard, mentioned above are to be agreed between customer and supplier.

All inputs and outputs are summarised in A.5.

7.3 Expansion devices

The inputs and rules for the design of expansion devices are given in prEN 13232-8.

7.4 Other components

The customer shall refer to the technical specifications that apply for following components, as far as applicable:

- rails;
- rail fastenings;
- bearers;
- welds;
- screws;
- studs;
- sliding chairs;
- baseplates;
- insulating joints.

If no elements are given for one or more of these components, the following standards shall apply:

Table 2 — Relevant EN's for components

Component	Relevant standard	Option
Vignole railway rails 46 kg/m and above	EN 13674-1	
Switch and crossing rails used in conjunction with Vignole railway rails 46 kg/m and above	EN 13674-2	
Check rails	EN 13674-3	
Vignole railway rails from 27 kg/m, but excluding 46 kg/m	EN 13674-4	
Fastening systems	EN 13481	
Concrete sleepers and bearers – Pre-stressed bearers for switches and crossings	EN 13230-4	
Wood sleepers and bearers	EN 13145	
Aluminothermic welding of rails	Series prEN 14730	

7.5 Output – assembly documents

7.5.1 Main assembly documents

At the end of the detailed design of the S&C layout, the supplier shall supply all the following information:

- assembly documents;
- parts list for the layout.

The assembly documents contains following minimum information:

- rail profile;

- materials and grades including heat treatments;
- setting out diagram;
- geometry (curvature);
- offsets at given dimensions;
- running edge openings at switches and crossings;
- track gauge;
- functional and safety dimensions (see Clause 8);
- tangent points;
- rail lengths;
- position of change of rail inclination;
- check rail lengths;
- position of parallel check rail length;
- position and type of joints and welds;
- joint gaps;
- position and type of anti-creep devices;
- bearer type;
- bearer position and number;
- bearer length;
- nominal bearer end position;
- baseplate type and position;
- type of baseplate fixation;
- rail fastenings;
- type and location of rail pads and baseplate pads;
- crossing type;
- actuation, locking and detection positions.

All positions are given to a reference basis, defined by the supplier.

The part list shall contain the following minimum information:

- part number;
- part name;

- plan number (if required);
- number of parts.

7.5.2 Optional documents

Only when clearly requested in the tender documents, the supplier shall deliver the following additional information:

- maintenance documents;
- handling documents;
- detailed component plans;
- part lists for component plans.

8 Acceptance (step 4)

8.1 Inputs

8.1.1 Documents and plans

Assembly documents as defined in 7.5 form the basis of acceptance testing.

These assembly documents will be accompanied by all detailed component plans that are within the limits of supply.

8.1.2 Limits of supply

The limits of supply shall be clearly specified in the tender documents.

8.2 Acceptance testing

8.2.1 Components acceptance

All components are accepted according to the relevant specifications or standard. All necessary tests are performed and certificates delivered as requested by these documents.

The following general tolerances apply to all other components of the S&C.

Table 3 — General acceptance tolerances

Parameter	Tolerance
Rail lengths (up to 24 m)	± 3 mm
Rail lengths (> 24 m)	± 4 mm
Diameter of fishbolt holes	+ 1/- 0,5 mm
Holes position relative to fishing surface	± 1 mm
Holes position relative to end of rail (for temporary fishplating)	± 1,5 mm (± 3 mm)
Chamfer of the holes	min. 0,5 mm
Surface roughness of machined wheel contact areas	Ra 6,3
NOTE Chamfer of holes is not needed in case of cold hole expansion.	

8.2.2 Layout assembly acceptance

8.2.2.1 General principles

The layout shall be assembled for inspection. This can be performed in a factory or at field site, according to the customer's requirements. The assembly shall be performed on the whole layout, when possible. If this is not possible, customer and supplier shall agree on assembly requirements.

8.2.2.2 Assembly and test conditions

During assembly the different components shall be handled correctly so that no permanent deformation is induced.

The assembly shall be performed on a horizontal and plane surface, according to the specifications given in the tender documents.

A reference basis shall be established using either a chord or two reference points at assembly site.

The tolerances are based on workshop temperatures or a predefined reference temperature θ specified by the customer.

In case this condition cannot be met, all lengths shall be corrected in accordance to following equation:

$$L = L_{\text{nom}} [1 + \alpha \times (T_A - T_R)] \quad (12)$$

where

$$\alpha = 1,15 \times 10^{-5}/\text{K};$$

T_A is the temperature at assembly;

T_R is the reference temperature;

L_{nom} is the nominal length as given on the assembly documents.

All measures are checked at the reference plane except when stated otherwise.

The test equipment shall be proposed by the supplier and approved by the customer.

8.2.2.3 Acceptance criteria

8.2.2.3.1 General comments

This subclause defines the tolerances of the critical dimensions that shall be verified.

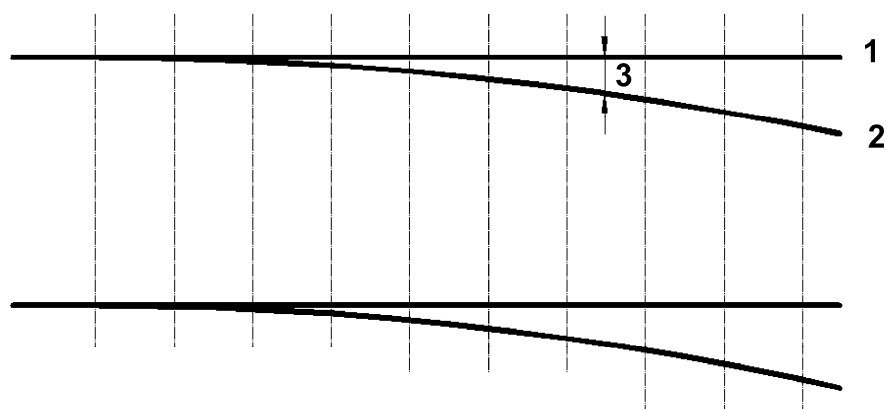
Any dimensions and tolerances relating to special requirements (e.g. operating systems) shall be verified.

If the customer imposes restrictions on the tolerances given in the following, they shall be stated in the tender documents.

8.2.2.3.2 Geometry checking

The general geometry is checked by:

- alignment of the reference (lead) rail to the reference line;
- offsets from the other rails to the reference rail (see Figure 38);
- track gauge;
- length of layout.



Key

- 1 reference rail
- 2 “curved” rail
- 3 offset

Figure 38 — Offset

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Table 4 — Geometry acceptance tolerances

Parameter	Tolerance (mm)
Alignment of reference rail	± 3
Offsets to reference rail	± 1
Gauge	± 2
Deviation of track gauge Between 2 bearers Over the whole layout	1 3
Lead ≤ 36 m > 36 m	± 10 ± 15
Track distance	+ 5/0

8.2.2.3.3 Functional and safety dimensions (FSD) – checking

Functional and safety dimensions (FSD) are safety critical. The choice for the limiting value depends on national and international regulations.

Nominal values for FSD and their fabrication tolerances have their influence on the maintenance frequency and are therefore the result of an economic choice. Their choice shall be based on the limits and belong to the customer in view of his maintenance policy. Practically used values on some European networks are given in Annex C.

All FSD's given in Table 5 shall be checked.

Free wheel passage can be either checked:

- by checking the free wheel passage itself;
- or by checking the flangeway.

The latter is most common for fabrication tolerances.

Table 5 — Functional and safety dimensions

Parameter	Symbol
Free wheel passage in switch area	F_{wps}
Flangeway at the open switch tongue	f_s
Fixed common crossing nose protection	N_{pcf}
Free wheel passage at common crossing nose	F_{wpcf} F_{wpccmp}
Free wheel passage at check rail entry	F_{wpcrc}
Flangeway at check rail entry	f_{cre}
Free wheel passage at wing rail entry	F_{wpwre}
Flangeway at wing rail entry	f_{wre}
Fixed obtuse crossing nose protection	N_{pof}
Free wheel passage at fixed obtuse crossing nose	F_{wpof}
Switch point relief	$A2$
Lateral point retraction	E
NOTE Values and tolerances, see Annex C.	

8.2.2.3.4 Gaps and clearances

In order to guarantee that no deformed parts would cause malfunctioning, the following gaps and clearances shall be checked.

Some values could be insufficient, depending on the ALD-system used. These shall be imposed by the ALD-system and are not included in the following table.

Table 6 — Tolerances for gaps, squareness etc.

Parameter	Tolerance
Squareness of switches at drive positions	± 2 mm
Squareness of front and heel joints	± 5 mm
Bearer squareness	± 5 mm
Bearer spacing	± 10 mm
Switch – stock rail contact allowance ^a	≤ 1 mm
Contact of switch studs ^a	≤ 1 mm
Vertical gap at sliding chairs	≤ 1 mm
^a For inspection the tongue shall be fixed to the stock rail at the drive position.	

8.3 Outputs

8.3.1 Documents

Acceptance documents for both assembly and components shall be agreed between customer and supplier.

These documents shall make note of all items to be checked and the corresponding measured values. When during inspection rework has been performed, this will be noted on the acceptance form.

An example of an assembly acceptance form is given in Annex B.

8.3.2 Traceability

The following items are permanently marked with a unique number to permit tracing of the product after installation:

- switch and/or stock rail;
- crossings.

The minimum information shall be in accordance to EN 13232-5, EN 13232-6 or EN 13232-7.

Other components are marked according to the technical specifications that apply.

8.3.3 Markings

The following items are marked to permit final assembly:

- bearer number as well as the number of the corresponding S&C is marked on every bearer;
- positions of bearers are marked at the rail foot in order to facilitate assembly;
- relative position from the switch to its corresponding stock rail (tolerance ± 1 mm);

These markings shall be agreed between customer and supplier.

Annex A (informative)

Design criteria

A.1 Geometry design

The inputs for geometry design are given in EN 13232-2 and are summarised as follows:

- track gauge;
- speed;
- max. cant deficiency;
- max. rate of change of cant deficiency;
- intersection point;
- angle;
- limits of supply;
- gauge variation.

When applicable, the following information shall be provided:

- track centres;

as well as:

- main line curvature;
- main line cant and branch line cant.

Figure A.1 summarises the geometry design process.

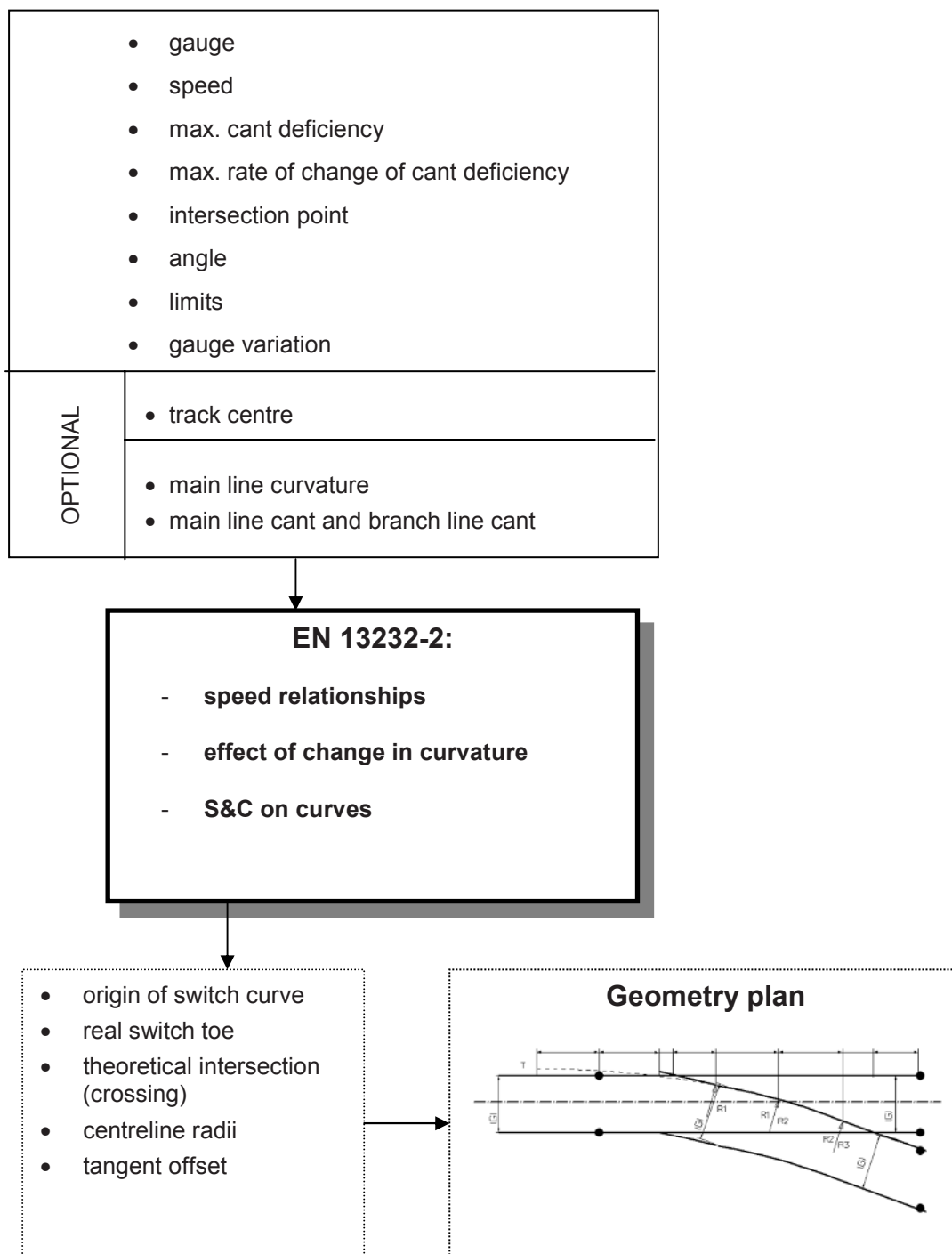


Figure A.1 — Geometry design process

A.2 Wheel rail interaction

The inputs for wheel rail interaction are given in EN 13232-3 and are summarised as follows:

- a) wheel dimensions:
 - flange width, height and angle;
 - tyre width and tread angle;
 - wheel diameter or radius;
 - back-to-back;
 - axle spacing and number of axles;
 - clearance of middle axles;
 - bogie spacing and min. curve radius for vehicles;
- b) track dimensions:
 - centre line radius;
 - gauge;
 - dimension of nose protection;
 - wing flangeway;
 - max. check rail height;
- c) tolerances and wear:
 - worn wheel profiles;
 - worn rail profiles;
 - (vertical and horizontal) wheel and rail wear;
- d) contact zone:
 - contact profile;
 - contact danger zone ;
- e) In addition, following information shall be given:
 - flange sharpness q_R ;

Figure A.2 summarises the wheel rail interaction.

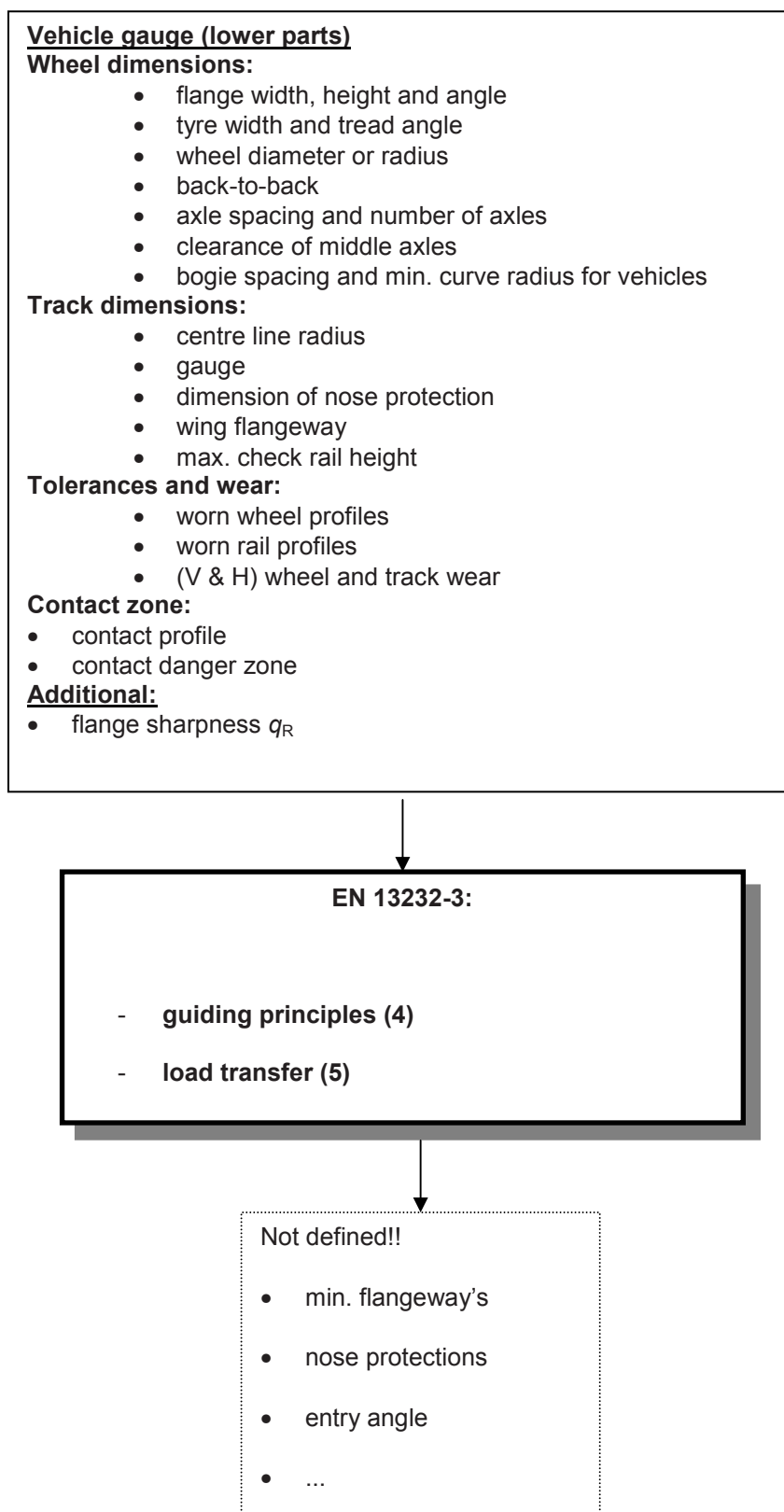


Figure A.2 — Wheel rail interaction

A.3 Actuation, locking and detection conformity

The inputs for actuation, locking and detection are given in EN 13232-4 and are summarised as follows:

The customer will provide following information:

- free wheel passage;
- maximum cant;
- maximum speed $V_{\max}$;
- trailability (i and V_{trail}),
- switch toe profile;
- obstacle dimension d .

From the actuation, locking and detection design process, the following information will be passed to permit a correct conformity check:

- locking system layout;
- detection layout;
- actuation layout;
- F_{cap} ;
- F_{a} ;
- mechanical interface;
- f_{p} and f_{d} ;
- d_{toe} ;
- F_{Neg} and f_{N} .

The stiffness and moveable length will have to be passed to permit the correct ALD-design. The latter forms no part of this standard although.

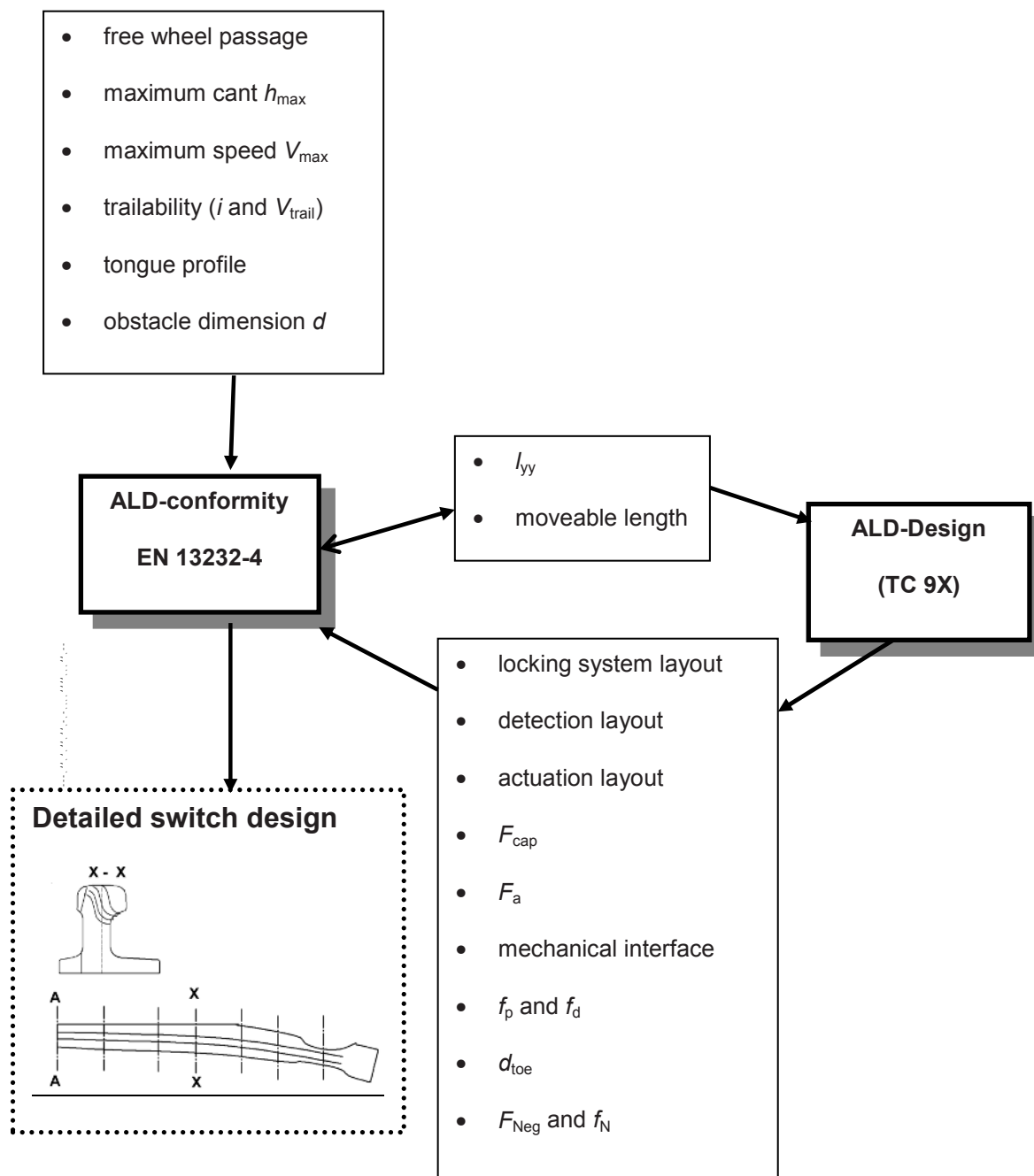


Figure A.3 — Actuation, locking and detection conformity

A.4 Switch design

The inputs for switch design are given in EN 13232-5 and are summarised as follows:

- axle loading;
- speed and cant deficiency;
- supports and fastenings;
- rail profiles;
- overall length;
- hand of switch;
- main line radius;
- gauge;
- rail inclination;
- free wheel passage;
- materials;
- maximum throwing force;
- toe opening;
- mechanical interface with ALD;
- special equipment;
- type of bearers/position;
- fastening system;
- type of switch (flexible/spring);
- jointing (welded/fishplated);
- insulating joints;
- trailability;
- environmental conditions;
- special maintenance conditions;
- special maintenance requirements.

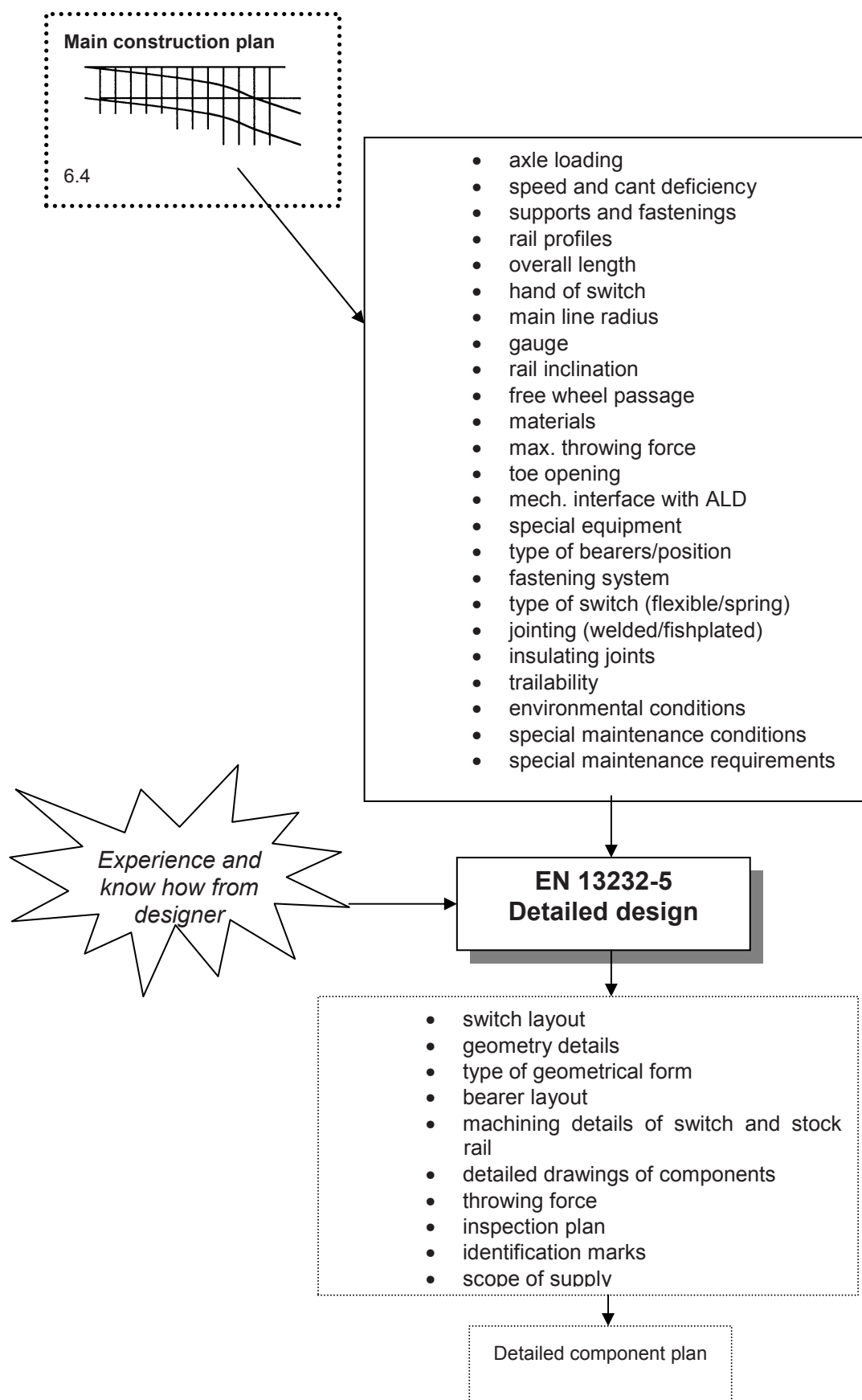


Figure A.4 — Switch design

A.5 Crossing design (with fixed parts)

The inputs for crossing design in the case of crossings with fixed parts are given in EN 13232-6 and are summarised as follows:

- crossing type;
- construction principle;
- type of joints;
- materials;
- geometrical data;
- supporting system;
- measuring instruments;
- record with critical measurements;
- examination methods;
- certifications;
- identification marks.

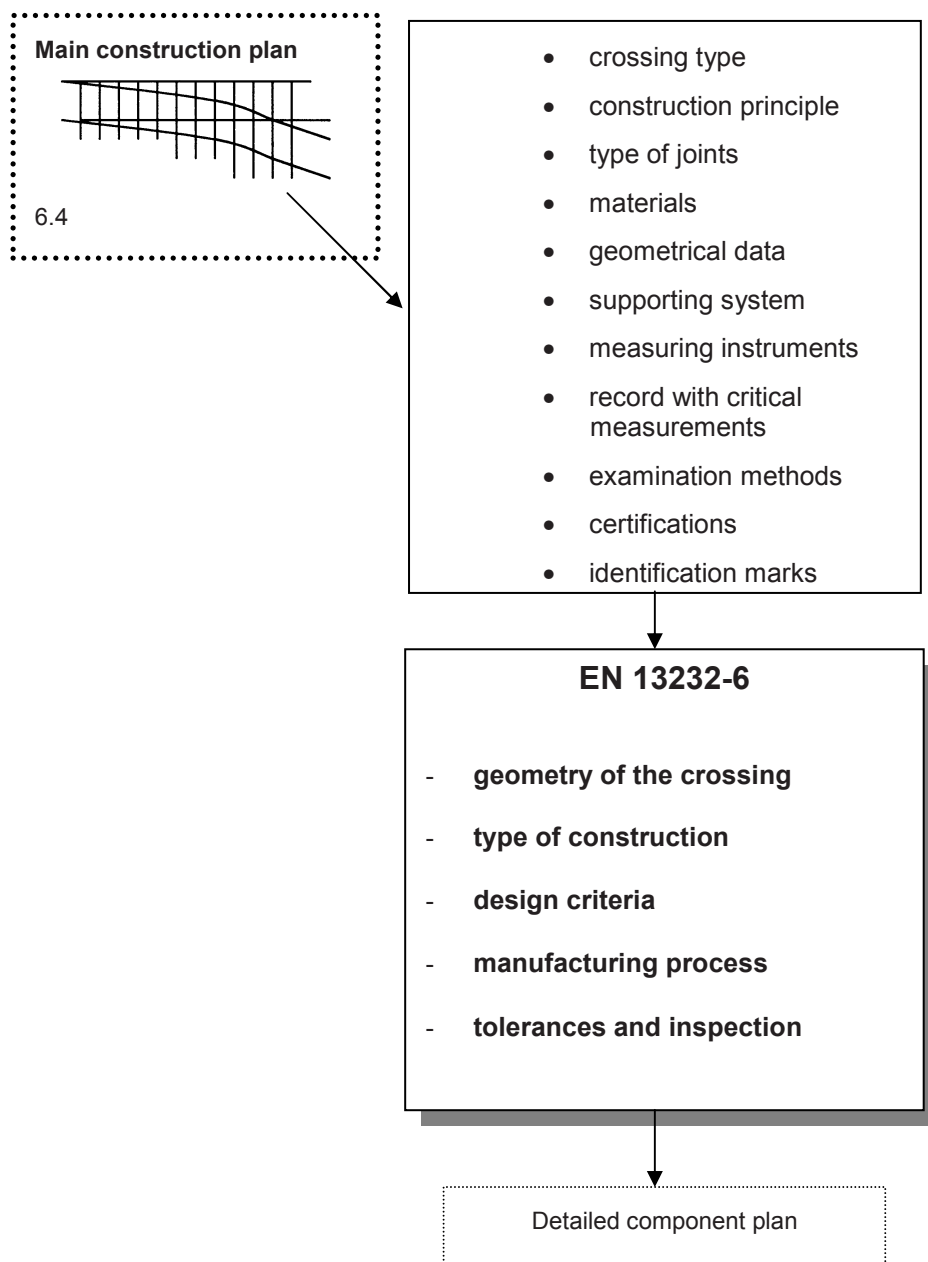


Figure A.5 — Fixed crossing design

A.6 Crossing design (with moveable parts)

The inputs for crossing design in the case of crossings with moveable parts are given in EN 13232-7 and are summarised as follows:

- crossing type;
- construction principle;
- type of joints;
- materials;
- geometrical data;
- running edges;
- bearer layout;
- gauge plate position;
- crossing height;
- rail profile and inclination;
- track gauge;
- check gauge;
- minimum flangeway;
- minimum throat opening,
- opening at drive position;
- supports and fastenings;
- maximum axle load,
- maximum speed;
- wheel profile, diameter, back-to-back and wheel set dimensions;
- interface with moveable parts.

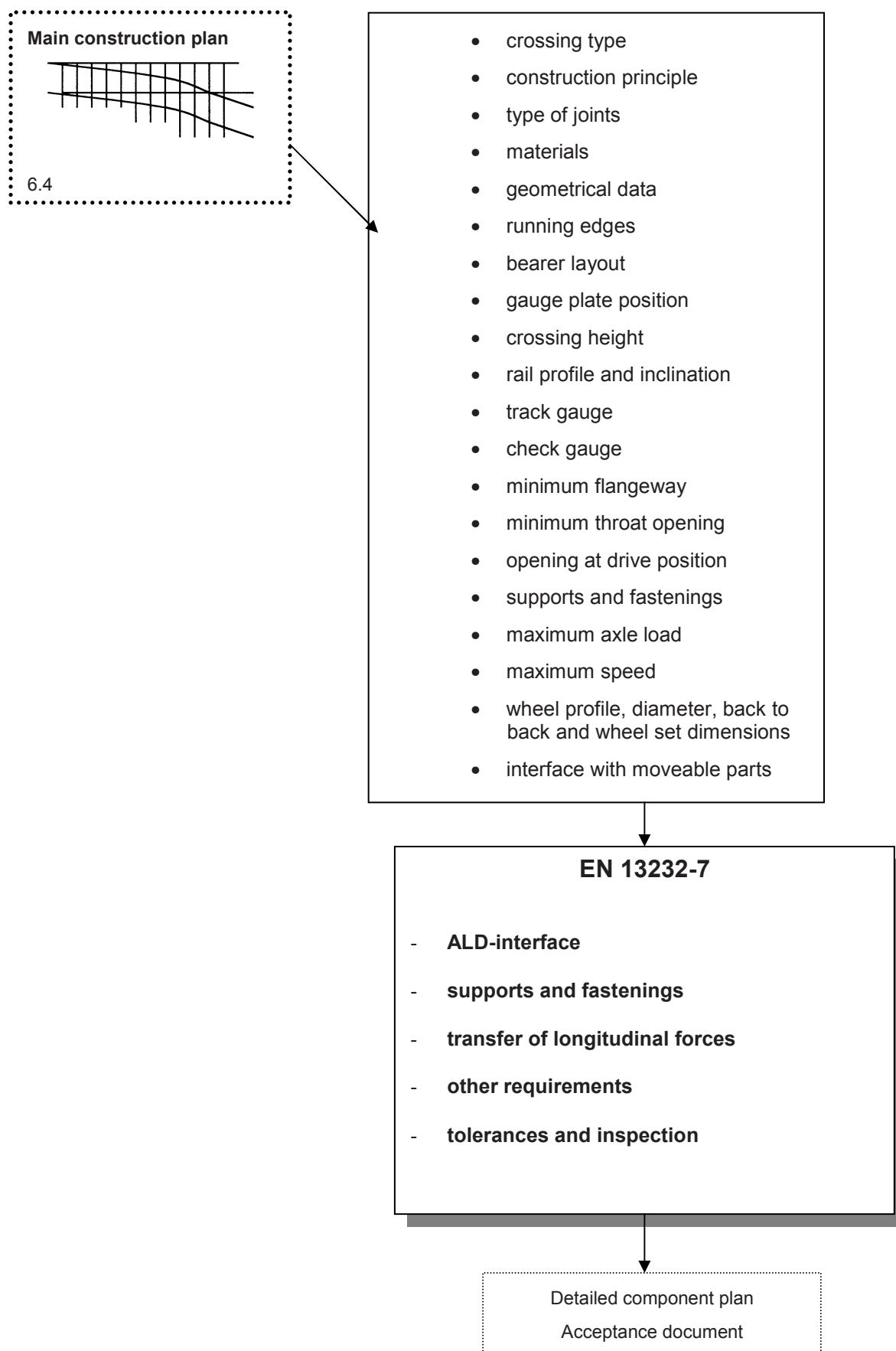


Figure A.6 — Crossing design with moveable parts

A.7 Expansion devices

See prEN 13232-8.

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Annex B **(informative)**

Layout acceptance form

B.1 Justification

There exists no general applicable acceptance form.

This European Standard gives all parameters that are to be checked during acceptance.

The checking frequency, location and the additional information to be taken and written down on the form, depend strongly on the methodology used, such as the measuring instruments, the mounting situation (in fabrication plant or at track site), the applicable quality system etc. Many of these will be stated in the tender document, if not, they will be agreed between customer and supplier.

Two main types of forms can be recognised:

- An exhaustive type, representing all values to be checked and including sketches of the layout type to be checked. This form is only applicable to the given layout.
- A second type of form delivers only a shortlist of the main items to be noted. This acceptance form shall always be accompanied by the layout assembly plans, on which the main dimensions are given, and on which variances from nominal value shall be noted during acceptance testing.

Next subclause gives one typical example for information only.

In any case, the acceptance form shall be agreed between customer and supplier.

B.2 Example of layout acceptance form

Customer	Layout Acceptance Form		Supplier	
General data		Identification		
Layout type		ID Customer		
Assembly drawing nr		ID Supplier		
Acceptance file nr		Order nr / date:		
Checklist				
<i>Checks</i>	<i>Nom</i>	<i>Tol</i>	<i>OK</i>	
Rail foot markings				
Total length				
Lead				
Joint gaps				
Bearer spacing				
Remarks and comments				
<i>Repairs and retrofits</i>				
Approval				
	<i>For the supplier</i>	<i>For the customer</i>		
Signature				
Name				
Function				
Date				

Alignment			Gauge			
Point	OK		Point	Main l. Nom (tol)	Branch l. Nom(tol)	OK
P1			G1			
P2			G2			
P3			G3			
P4			G4			
P5			G5			
P6			G6			
			G7			
			G8			
			G9			
			G10			
			G11			
			G12			
			G13			
Squareness			Offset			
	Tol	OK	Point Nr.	Bearer Nr.	Offset	OK
FJ	± 5		O1	45		
EJ	± 5		O2	41		
ALDS	± 2		O3	37		
Bearer	± 5		O4	33		
			O5	29		
			O6	25		
			O7	21		
			O8	17		
Functional and Safety Dimensions						
Param.	Nom	(tol)	OK			
F_{wps}						
N_{pcf}						
F_{wpcf}						
f_{cre}						
f_{wre}						

Annex C (informative)

Functional and safety dimensions, practically used by different European Networks

Table C.1 — Practically used values for FSD's on European Networks (mm)

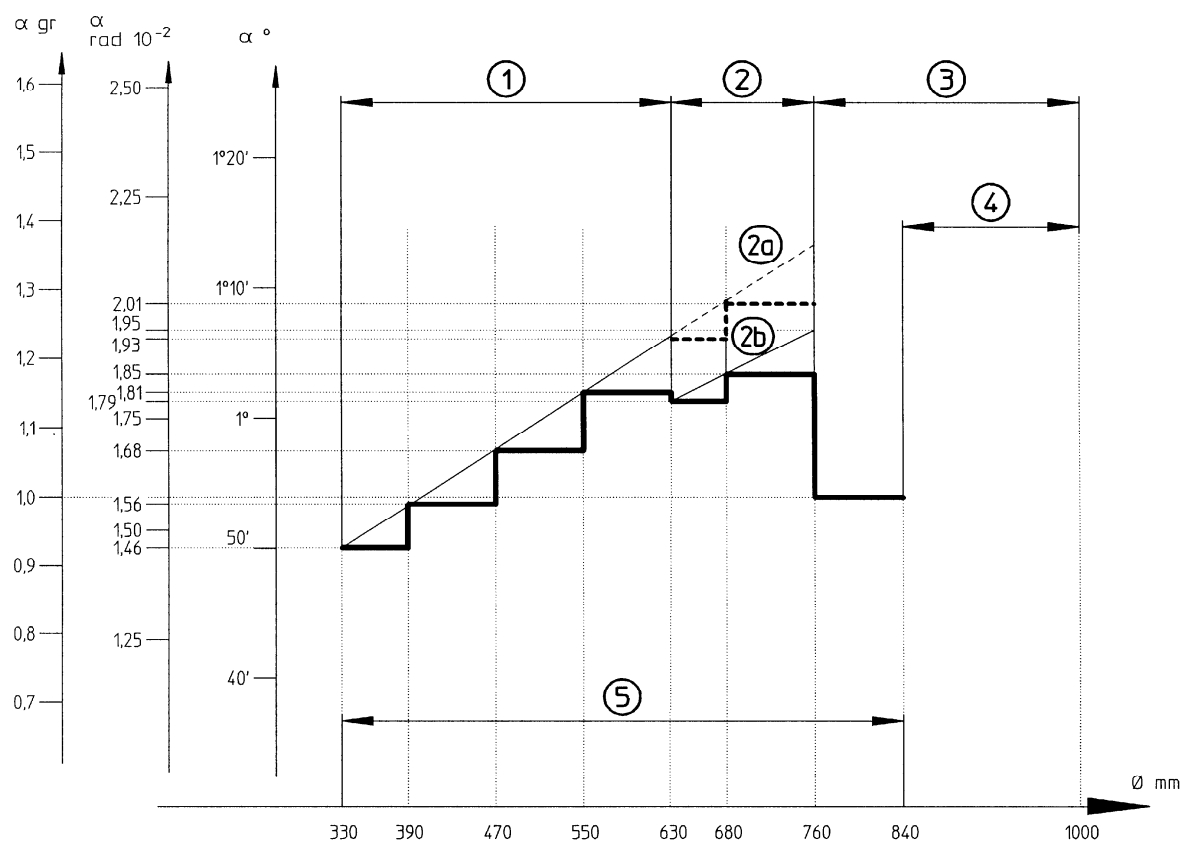
Parameter	Symbol	NMBS	DB	ÖBB	Network Rail	SNCF	Bane-styrelsen	CD
Free wheel passage in switch area Flangeway at the open switch tongue	F_{wps} f_s	$\leq 1\,365^a$	≥ 58	$\leq 1\,373$	$\leq 1\,375$	$\leq 1\,380$	≥ 60	≥ 60
Fixed common crossing nose protection	N_{pcf}	$1\,395^{+1}_0$	$1\,396^{+1}_{-1}$	$1\,394^{+3}_0$	$1\,391^{+3}_0$	$1\,395 \pm 0,5$	$1\,394^{+1}_0$	$1\,396^{+1}_{-1}$
Free wheel passage at common crossing nose	F_{wpcf} F_{wpcmp}	$\leq 1\,356$	$1\,354^{+2}_{-1}$	$\leq 1\,356$	$\leq 1\,350$	$\leq 1\,356$	$\leq 1\,356$	$\leq 1\,356$
Free wheel passage at check rail entry Flangeway at check rail entry	F_{wpcr} f_{cre}	75^{+3}_0	65^{+3}_0	60^{+3}_0		$1\,370 \pm 3$	80^{+3}_0	58^{+3}_{-1}
Free wheel passage at wing rail entry Flangeway at wing rail entry	F_{wpwr} f_{wre}	75^{+3}_0	65^{+3}_0	60^{+3}_0		65^{+3}_0	80^{+3}_0	58^{+3}_{-1} 80^{+3}_0
Fixed obtuse crossing nose protection	N_{pof}	$1\,397^{+2}_{-0,5}$	$1\,396^{+1}_{-1}$	$1\,394^{+3}_0$	$1\,391^{+3}_0$	$1\,395 \pm 0,5$	$1\,394^{+1}_0$	$1\,396^{+1}_{-1}$
Free wheel passage at fixed obtuse crossing nose	F_{wpof}	$\leq 1\,356$	$1\,354^{+2}_{-1}$	$\leq 1\,353$	$\leq 1\,353$	$\leq 1\,356$	$\leq 1\,356$	$\leq 1\,356$
Switch point relief	$A2$	≤ 25	≤ 23	25		22	22	23
Lateral point retraction	E	3	3	5	0	3	3	3

^a May vary depending on construction type

Annex D (normative)

Maximum angle of attack in obtuse crossings

The maximum truck swing, occurring in vehicles in accordance with UIC 510-2, with wheel diameters between 330 mm and 840 mm, and permitted to pass through obtuse crossings with an angle of at least tangent 0,11 or 1 in 9 are given in Figure D.1.



Key

- α wheel swing
- ϕ wheel diameter
- 1 flange profile – Flange height of 32 mm
- 2 zone with one of following two profiles
- 2a flange profile in accordance to EN 13715 with flange height of 32 mm
- 2b flange profile in accordance to EN 13715 with flange height of 30 mm
- 3 flange profile in accordance to EN 13715 with flange height of 28 mm
- 4 no swing defined
- 5 a transversal movement of 20 ‰ and $H_y \leq 0,25 \times 2Q_0$ shall be considered

Figure D.1 — Maximum truck swing

These values apply to a wheel back to back of 1 363 mm.

The flange profile depends on the wheel diameter. For wheels with diameters from 630 mm to 760 mm, two profiles can be used.

To check the security for derailment, a transversal movement of 20 ‰ shall be taken into account as well as a horizontal force, smaller than 25 % of the wheel load.

75

Annex ZA **(informative)**

Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2008/57/EC¹.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 for HS Infrastructure and in Table ZA.2 for CR Infrastructure confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

¹ This Directive 2008/57/EC adopted on 17th June 2008 is a recast of the previous Directives 96/48/EC 'Interoperability of the trans-European high-speed rail system' and 2001/16/EC 'Interoperability of the trans-European conventional rail system' and revisions thereof by 2004/50/EC 'Corrigendum to Directive 2004/50/EC of the European Parliament and of the Council of 29th April 2004 amending Council Directive 96/48/EC on the interoperability of the trans-European high-speed rail system and Directive 2001/16/EC of the European Parliament and of the Council on the interoperability of the trans-European conventional rail system'.

Table ZA.1 — Correspondence between this European Standard, the HS TSI INF, published in OJEU dated 19th March 2008, and Directive 2008/57/EC

Clause(s)/ sub-clause(s) of this European Standard	Chapters/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
5 General design 5.1 Track layout 5.2 Geometrical design 5.3 Wheel/rail interaction 6 Main constructional design 7 Detailed component design 8 Acceptance Normative Annex D Maximum angle of attack in obtuse crossings	4. Description of the infrastructure domain 4.2.2 Nominal track gauge 4.2.3 Minimum infrastructure gauge 4.2.7 Track cant 4.2.11 b) Rail inclination – Switches and crossings 4.2.12 Switches and crossings 4.2.13 Track resistance 5. Interoperability constituents 5.3.1.1.b) Railhead profile – Switches and crossings 5.3.2 The rail fastenings systems 5.3.4 Switches and crossings 6. Assessment of conformity and/or suitability for use of the constituents and verification of the subsystems 6.1.6.2. Assessment of fastening system Annex A – Table A1 Annex B1 – Table B1	Annex III Essential requirements 1. General requirements 1.1 Safety Clauses 1.1.1 – 1.1.2 and 1.1.3 1.2 Reliability and availability 1.5 Technical compatibility	The design of the actuation, locking and detection system is not dealt with within this European Standard EN 13232-4 defines the requirements for the conformity checking of the actuation, locking and detection system The detailed component design (Clause 7) is dealt with in parts 5, 6, 7 and 8 of EN 13232

Table ZA.2 — Correspondence between this European Standard, the CR TSI INF published in OJEU dated 14th May 2011, and Directive 2008/57/EC

Clause(s)/ sub-clause(s) of this European Standard	Chapters/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
5 General design 5.1 Track layout 5.2 Geometrical design 5.3 Wheel/rail Interaction 6 Main constructional design 7 Detailed component design 8 Acceptance Normative Annex D Maximum angle of attack in obtuse crossings	4. Description of the infrastructure subsystem 4.2.4.1 Structure gauge 4.2.5.1 Nominal track gauge 4.2.5.2 Cant 4.2.5.7 2 Rail inclination – Requirements for switches and crossings 4.2.6.2 In-service geometry of switches and crossings 4.2.6.3 Maximum unguided length of fixed obtuse crossings 4.2.7 Track resistance to applied loads 6. Assessment of conformity of the interoperability constituents and EC verification of the subsystems 6.2.4.7 Assessment of geometry of switches and crossings 6.2.5.2 Assessment of track resistance for switches and crossings	Annex III Essential requirements 1. General requirements 1.1 Safety Clauses 1.1.1 – 1.1.2 and 1.1.3 1.2 Reliability and availability 1.5 Technical compatibility	The design of the actuation, locking and detection system is not dealt with within this European Standard EN 13232-4 defines the requirements for the conformity checking of the actuation, locking and detection system The detailed component design (Clause 7) is dealt with in parts 5, 6, 7 and 8 of EN 13232 Rails, fastenings and sleepers used for short length of track or specific purposes, for example in switches and crossings, at expansion devices, transition slabs and special structures, are not considered to be interoperability constituents according to § 5.2 (3) of the CR TSI INF

WARNING — Other requirements and other EC Directives may be applicable to the product(s) falling within the scope of this standard. A1

Bibliography

- [1] EN 13230 (all parts), *Railway applications — Track — Concrete sleepers and bearers*
- [2] EN 13232-1, *Railway applications — Track — Switches and crossings — Part 1: Definitions*
- [3] UIC 711, *Geometry of points and crossings with UIC rails permitting speeds of 100 km/h or more on the diverging track*
- [4] UIC 716, *Maximum permissible wear profiles for switches*
- [5] ERRI C70 RP1:1970, *Mutually permissible wear profiles of wheel tyres and points of crossings – Assessment criteria for the permissible wear profiles of wheel flanges and switch components*

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